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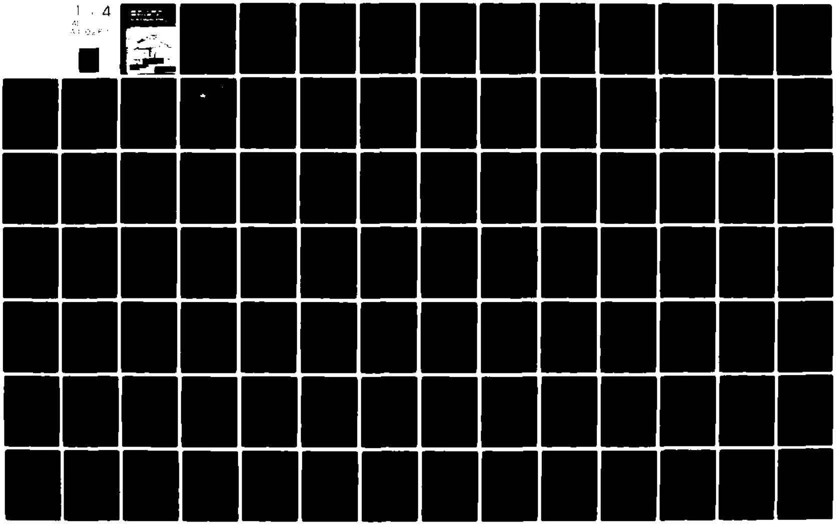

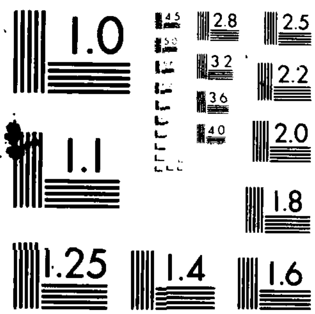

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GRAND FORKS – EAST GRAND FORKS URBAN WATER RESOURCES STUDY

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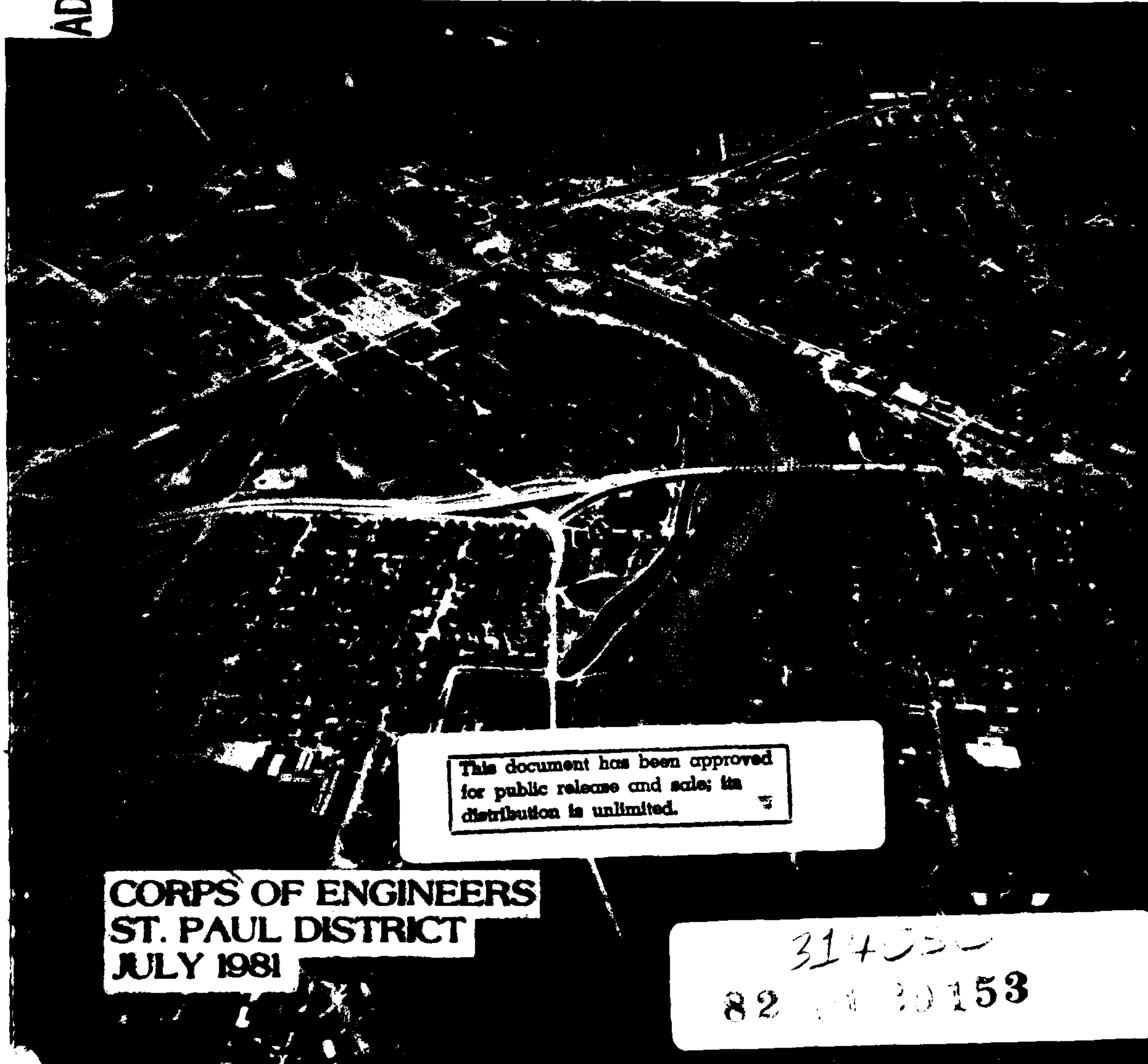

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The goal of the Corps of Engineers Urban Study Program is to provide planning assistance to local interests in a variety of water resource areas, some not within the traditional Corps areas of responsibility.

The wastewater appendix consists of two reports; Wastewater study-Problem Identification/ Alternative Formulation/ Evaluation and Wastewater Study-Grand Forks Combined Sewer Analysis Final Report (1980). Both reports are included in this appendix.

The stage 2 report covered major and intermittent point and nonpoint

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sources of pollutants. The study examined the capabilities of existing wastewater treatment facilities in the study area in light of wastewater load projections through 2030.

The study concluded that separate wastewater treatment facilities based on lagoon systems were the most cost-effective means of handling major point sources through 2030. However, if "zero discharge" criteria were promulgated the large land areas needed for lagoon effluent disposal could make advance mechanical treatment attractive.

Overflows from Grand Forks' combined sewers into the Red River, which is the city's drinking water source, were the most serious problems. The study's finding that the most cost-effective solution was sewer separation was accepted by the Environmental Protection Agency and the North Dakota State Department of Health, making the city eligible for Federal financial assistance.

This study reports is one of ten documents in the Grand Forks/ East Grand Forks Urban Water Resources Study.

PREFACE

The Corps of Engineers Urban Study Program is aimed at providing planning assistance to local interests in a variety of water and related land resource areas, including water supply, wastewater management, flood control, navigation, shoreline erosion, and recreation. In areas of traditional Corps responsibility (such as flood control), the Corps may implement and construct projects shown feasible in the urban study. In other areas (such as wastewater management), Corps involvement carries only through the planning stage; findings are turned over to local interests for incorporation into their broad urban comprehensive planning effort. Implementation is at the discretion of local interests in conjunction with appropriate State and Federal agencies.

The St. Paul District, Corps of Engineers, conducted the Grand Forks-East Grand Forks (GF/EGF) Urban Water Resources Study, which was a cooperative effort among local, State and Federal agencies. The GF/EGF urban study spanned a time of transition in the Corps' urban study program. In mid-1978, directives were issued deleting the third and last stage of urban studies. At that time, the second stage of the GF/EGF urban study was nearing completion, and commitments for stage 3 studies had been made to local interests and involved State and Federal agencies. Therefore, the GF/EGF urban study was allowed to proceed to stage 3.

During the first stage, the 14-township study area was selected, broad topical problems to be addressed (water supply, wastewater management, and flood control) were identified, and a "plan of study" was developed. The plan of study outlined the general approach the study would follow. During stage 2, the topical problems were broken down into explicit problem areas. Investigators formulated a broad array of alternatives to resolve the study area's problems. The alternatives were evaluated to eliminate those which were not suitable or cost effective. The stage 3 study examined in detail those alternatives that passed the stage 2 screening. Alternatives were reassessed to determine their respective cost-effectiveness and environmental/social impacts.

This particular document is 1 of 11 constituting the GF/EGF urban study report:

Summary Report
Background Information Appendix
Plan Formulation Appendix
Water Supply Appendix
Wastewater Management Appendix
Flood Control and Urban Drainage Appendix
Flood Emergency Plan for Grand Forks, North Dakota
City of East Grand Forks, Minnesota, Civil Defense Flood Fight Plan
Energy Conservation and Recreation Appendix
Public Involvement Appendix
Comments Appendix

This Wastewater Management Appendix consists of two reports prepared by Stanley Consultants, Incorporated, under contract to the St. Paul District, Corps of Engineers:

- Stage 2 Wastewater Study - Problem Identification/Alternative Formulation/Evaluation (August 1978) examined the wastewater and urban runoff problems of the entire study area relative to the communities' existing and planned treatment and stormwater runoff facilities.

- Stage 3 Wastewater Study - Grand Forks Combined Sewer Analysis Final Report (April 1980) focused on solutions to discharges from Grand Forks' combined sewer system.

Both reports are included in this appendix to provide the reader with a complete sequential picture of the planning effort during the urban study. Minor editoral corrections have been made in these reports; otherwise, they are unchanged. While reading these reports, the reader may encounter repetitious or apparently contradictory material. Such cases reflect the iterative analytical process which relied on an evolving data bank.

The stage 2 report covered major and intermittent point and nonpoint sources of pollutants. The study examined the capabilities of existing wastewater treatment facilities in the study area in light of wastewater load projections through 2030. It concluded that separate facilities based on lagoon systems were the most cost effective means of handling major point sources, although if the "zero discharge" criteria were promulgated the large land areas needed for lagoon effluent disposal could make advanced mechnical treatment attractive. Since local plans for future wastewater treatment works were already based on the most cost effective approach, further study of major point sources in stage 3 was considered unnecessary.

Stage 2's investigation of intermittent point and nonpoint sources showed that overflow of Grand Forks' combined sewers was the most serious problem. Preliminary analyses showed that separation of the combined sewers provided the best solution to this problem. The city's July 1978 request to the EPA (Environmental Protection Agency) that the stage 2 report be accepted as meeting the step 1 requirements of EPA's Construction Grants Program was denied. Meetings between the EPA, Corps, State Department of Health, and city officials culminated in a memorandum of understanding on additional studies needed to meet the step 1 requirements. The resulting report reaffirms sewer separation as the most cost-effective solution to the combined sewer overflow problem. This report was reviewed and accepted by the EPA and the State Department of Health, making the city eligible for Federal financial assistance for the separation project.

Because Corps involvement in wastewater management carried only through the planning stage, the Corps was not required to prepare an environmental impact statement. Therefore, the impact assessment discussion in this appendix should not be considered a definitive or final environmental/social impact evaluation of the alternatives and recommended plans. This discussion, however, does indicate areas of special concern that may require further study. Agencies involved in implementing any of the alternatives should comply with applicable requirements of the National Environmental Policy Act of 1969 (Public Law 91-190) and subsequent legislation.

The St. Paul District has completed a cultural resource literature search, record review, and reconnaissance-level survey of the area. Thirty-three historic and prehistoric sites were identified within the cities' limits. These sites should be considered during implementation and project plans should be coordinated with the North Dakota and Minnesota State Historic Preservation Officers. Additional cultural resource surveys may be needed before construction.

Recreational opportunities and impacts on existing facilities should be considered in any implmentation plans; for instance, trail systems might follow project rights-of-way. The improvement in water-related recreation along the Red River of the North attributable to reductions in combined sewer discharges should be evaluated.

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INTRODUCTION

GENERAL

The St. Paul District, Corps of Engineers, conducted the Grand Forks-East Grand Forks Urban Water Resources Study, which identified water resource problems in the urban study area, projected water resource needs, and provided alternative plans and programs to best meet those needs. This report focuses on identifying problems and needs of the urban study area and formulating alternative solutions to those problems and needs related to water quality management.

SCOPE

The specific scope of this report includes:

1. Review of existing information to identify:
   a. Existing wastewater treatment facilities in the study area and their performance and effluent criteria.
   b. Areas served by combined sewers, sanitary sewers, and storm sewers.
   c. The sources and magnitude of point and nonpoint sources.
2. Use of existing data to describe as completely as possible:
   a. The impact of rainfall events on the sewerage systems of Grand Forks and East Grand Forks.
   b. The separate and combined impacts of storm sewers, combined sewer overflow, and nonpoint sources as a result of rainfall runoff.
   c. The separate and combined impacts of wastewater discharges.
3. Where existing data are lacking to accomplish item 2, use of literature data to describe probable impacts and outline a data collection and analysis program for stage 3 analysis.

4. Projection of wastewater flow and load for each treatment facility in the study area and identification of needs for future upgrading or expansion.
5. Where water quality problems were identified above, outline of alternative ways to meet water quality criteria.
6. For the water quality and upgrading and expansion problems identified above, development of alternative ways to resolve problems. Primary consideration was given to:
    a. Type of treatment.
    b. Applicability of nonstructural controls.
    c. Service areas and degrees of regionalization.
    d. Sludge management.
    e. Preliminary costs of systems.
7. For the alternatives developed above, identification of the gross impacts on the natural and cultural environment of the study area.
8. Selection of alternatives to be evaluated in more detail in Stage 3 studies.

STUDY AREA

The urban study area as established in the "Plan of Study" (1) includes Grand Forks, Huntsville, Rhinehart, and Sullivan Townships of Polk County, Minnesota, and Blooming, Brenna, Chester, Falconer, Ferry, Grand Forks, Mekinock, Oakville, and Walle Townships of Grand Forks County, North Dakota (see figure 1). Major population centers in the study area are the cities of Grand Forks, North Dakota, and East Grand Forks, Minnesota, and the Grand Forks Air Force Base near Emerado, North Dakota. A comprehensive overview of the study area is provided in the "Social and Environmental Inventory," July 1977 (2).

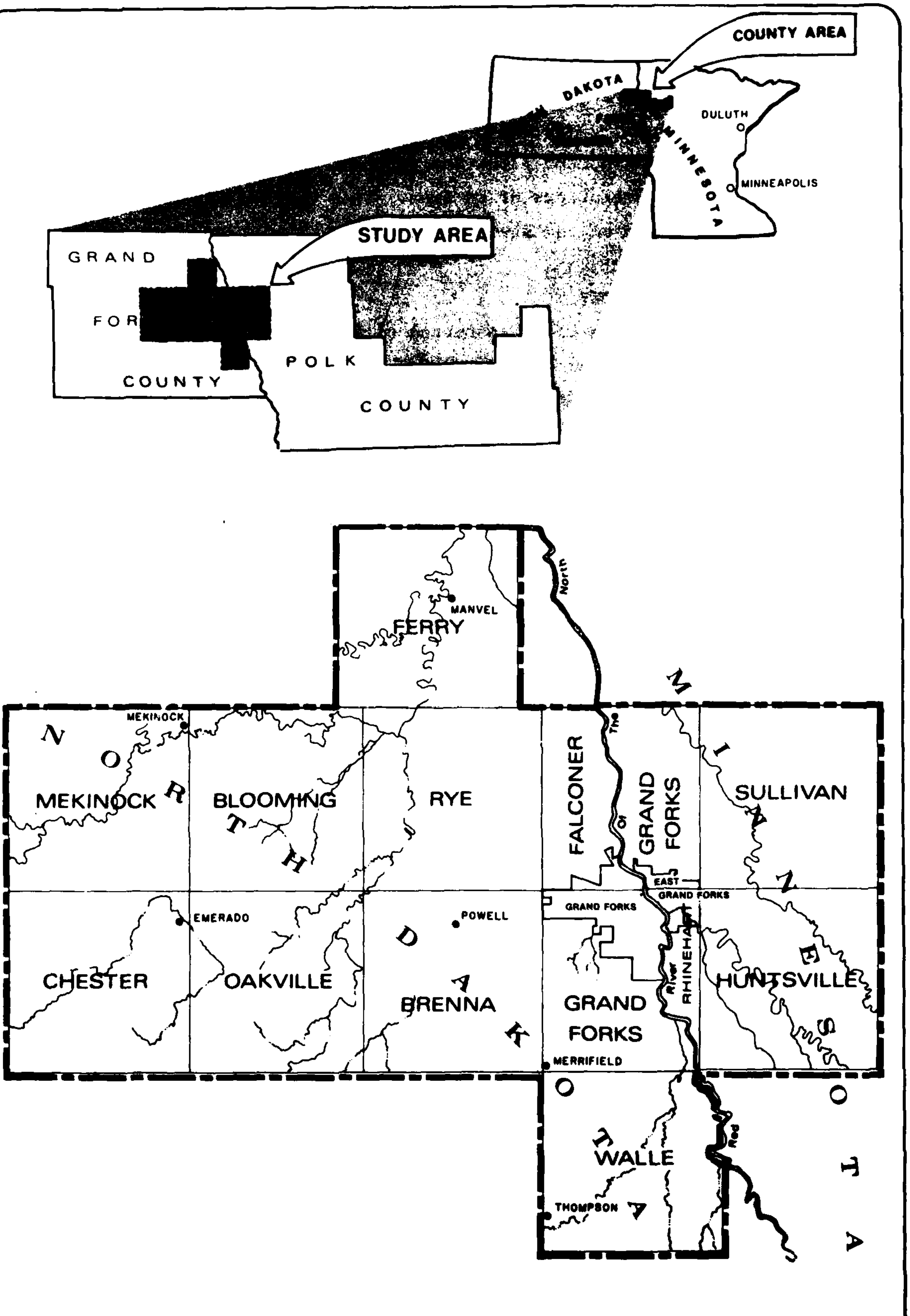


Figure 1 - Study Area

WATER RESOURCES OF THE STUDY AREA

GENERAL

Wastewater Management plans and programs are designed to maintain or enhance the water resources of an area. This section describes the existing water resources of the study area.

SURFACE WATER HYDROLOGY

The major surface water resources of the study area are the Red River of the North and the Red Lake River. The flow of these rivers is regulated by dams and reservoirs: Lake Ashtabula on the Sheyenne River, Lake Traverse on the Bois de Sioux River and Orwell Lake on the Ottertail River. Additional reservoirs are under study. The location of existing and potential reservoirs is shown on figure 2.

The flow of water in these and other surface water resources of the study area is influenced by reservoir operation and climatic factors. Low-flow information for the Red River of the North and Red Lake River is provided in table 1.

The water resources of the immediate study area (2) are shown on figure 3. The flow of the locally significant streams, including the Turtle River, English Coulee, Grand Marais Coulee, and the network of drainage ditches is extremely variable, responding to local rainfall and snowmelt. All are fairly sluggish streams having low velocities of flow because of the flat terrain. The 7-day, 10-year low flow of these surface water resources is at or near zero.

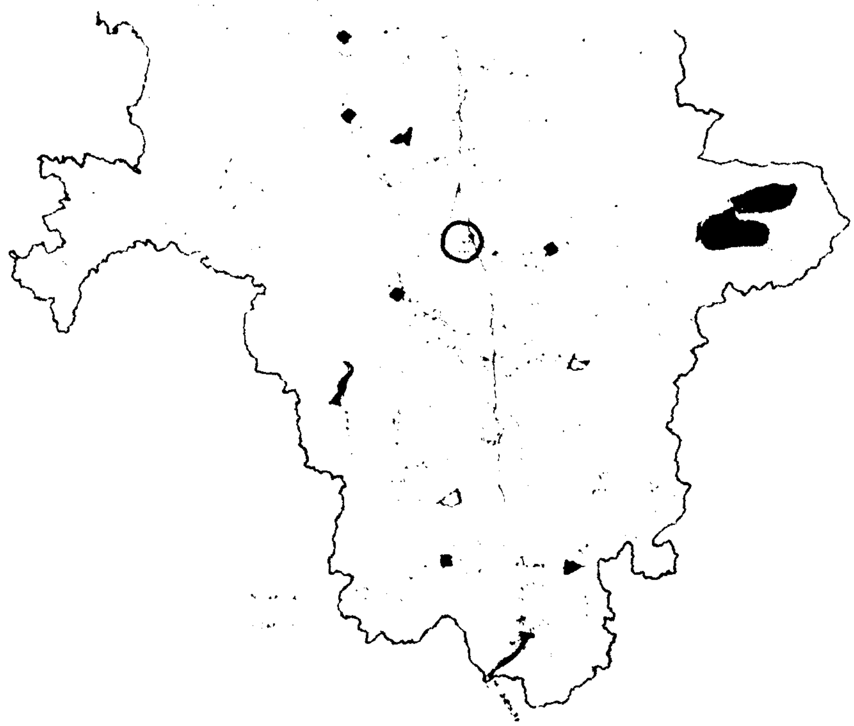
The average flow of the Red River of the North downstream of Grand Forks is approximately 2,500 cfs (cubic feet per second). A flow range from 2.4 cfs to 85,000 cfs has been recorded. The mean annual flow of the Red Lake River at East Grand Forks is about 1,250 cfs with ranges from 0 to 28,400 cfs (2).

Wastewater treatment facilities in the study area consist of controlled discharge lagoons which influence river flow and quality when they are discharging.

Table 1 - Magnitude and frequency of annual low flows at continuous-record gaging stations

Station Name	Record Used in Analysis	Drainage Area (sq mi)	Period (consecutive days)	Annual low flow, in cubic feet per second, for indicated recurrence in years: 2	5	10	20	50	100
Red Lake River at Crookston	1903-72 1975	5280	1	154	43.4	19.7	9.53	3.89	2.04
			7	207	60.2	27.6	13.4	5.52	2.90
			14	228	67.9	31.4	15.4	6.38	3.37
			30	257	80.1	38.0	19.1	8.12	4.37
			60	294	94.2	45.2	22.9	9.76	5.26
			90	330	107	51.4	25.9	11.0	5.88
			120	363	120	58.5	29.7	12.7	6.80
			183	427	144	71.0	36.6	16.0	8.71
			365	909	413	256	166	98.2	67.5
			(Flow partly regulated by outlet dam on Lower Red Lake)						
Red River of the North at Grand Forks	1905-75	30100	1	447	138	60.4	27.1	9.63	4.46
			7	478	147	64.8	29.3	10.5	4.90
			14	497	156	69.2	31.6	11.5	5.41
			30	530	172	77.9	36.2	13.5	6.48
			60	556	198	99.5	51.9	22.8	12.4
			90	607	224	115	61.2	27.6	15.4
			120	661	257	137	76.0	36.1	20.9
			183	798	302	156	83.6	37.7	21.0
			365	2,040	1,020	684	481	316	236
			(Flow regulated by many lakes and reservoirs on tributaries)						

Source: Reference (3).



MULTI-PURPOSE RESERVOIRS

EXISTING

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UNDER STUDY

Figure 2 - Red River Basin

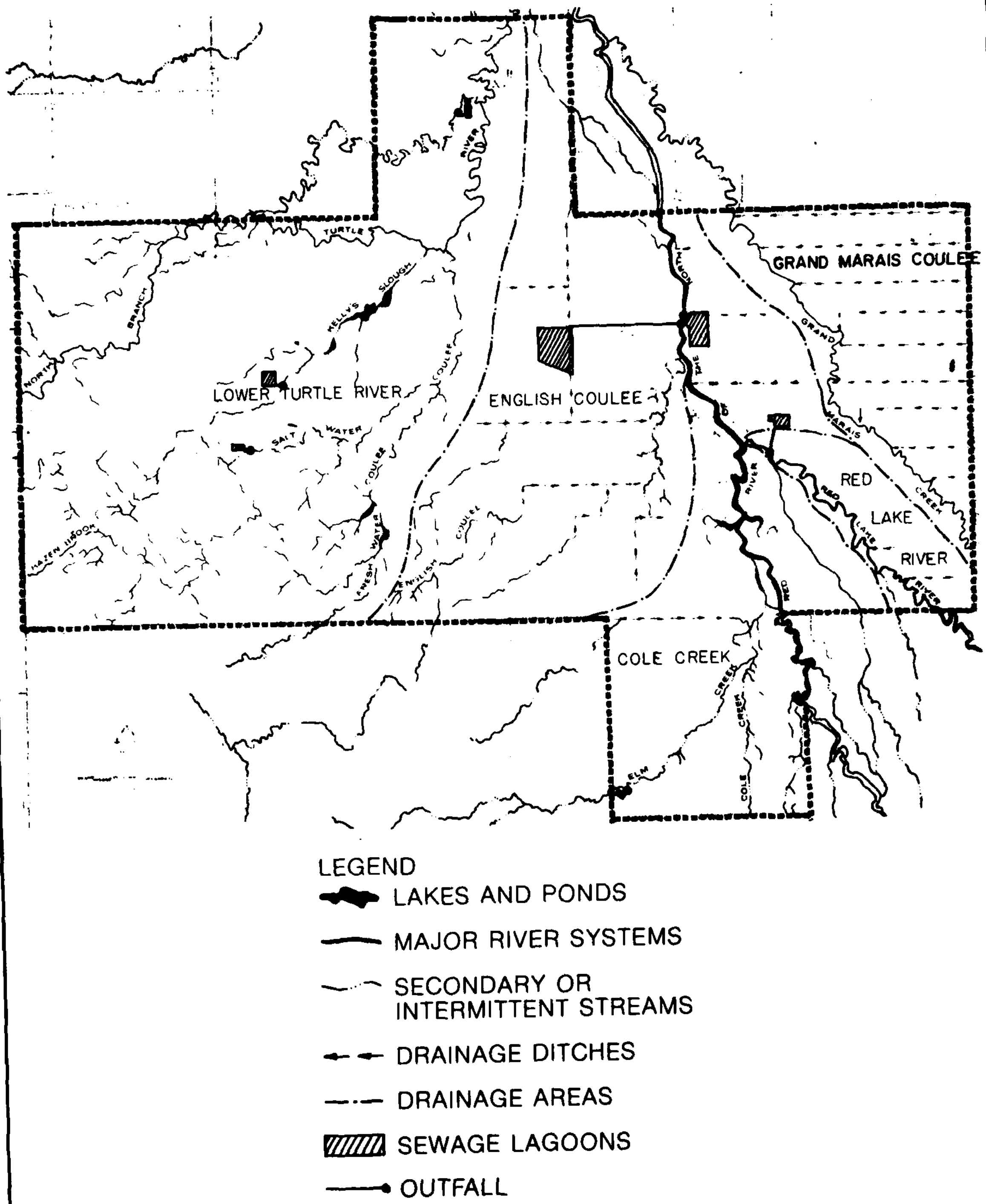


Figure 3 - Water Resources of the Study Area

The Garrison Diversion project, if completed in the 1980's, would supplement flow in the Red River of the North by diverting water from the Missouri River to the western extremities of the Sheyenne River. This project and its feasibility are still in question.

SURFACE WATER QUALITY

The quality of surface waters is measured by certain chemical, physical, and biological indicators at a number of sampling stations in the Red River basin. Selected sampling stations upstream of, within, and downstream of the study area are shown on figure 4. The averages and ranges of selected indicators for these stations are shown in table 2. Continuous sampling stations for flow, specific conductance, dissolved oxygen, temperature, and pH are located at the Grand Forks and East Grand Forks water treatment plant intakes. Most other samples are monthly grab samples.

By 1969, the fishery of the Red River had been largely eliminated by water pollution and lack of reaeration during winter ice cover. High levels of coliform bacteria indicated the river was not suitable for any recreational activity which involves water contact (5). Construction of more adequate wastewater treatment facilities is leading to improved water quality, but nonpoint source discharges and natural factors continue to inhibit the river's fishery. The base flow of area rivers in low flow periods is derived from groundwater which is high to extremely high in dissolved solids rendering the water quality less than suitable for water supply purposes at those times. The fine-clay nature of the stream beds leads to high turbidity in the rivers, inhibiting fish spawning. Ice cover inhibits reaeration and the organic load in the streams during these periods has been high enough in the past to consume all oxygen and lead to fish kills.

Water quality varies with flow in the rivers. A statistical analysis of the variation in selected water quality indicators for the Red Lake River at East Grand Forks and the Red River of the North at Grand Forks has been performed. The results are presented in table 3.

Table 2 - Surface Water Quality in the Study Area

Constituent	Red River at Perley[2] Average	Red River at Perley[2] Range	Red River at Halstead[3] Average	Red River at Halstead[3] Range	Goose River at Hillsboro[4] Average	Goose River at Hillsboro[4] Range	Red River at Grand Forks Water Intake[5] Average	Red River at Grand Forks Water Intake[5] Range	Red Lake River at Crookston[6] Average	Red Lake River at Crookston[6] Range	Red Lake River at East Grand Forks Water Intake[7] Average	Red Lake River at East Grand Forks Water Intake[7] Range	Red River at Grand Forks[8] Average	Red River at Grand Forks[8] Range	Turtle River at Manvel Average	Turtle River at Manvel Range	Red River at Oslo Average	Red River at Oslo Range
Flow (cfs)	--	--	5,690	23-39,900	379	0.07-3,209	1,562	310-5,470	2,148	474-15,150	779	75-6,530	4,427	175-54,000	160	0.2-1,450	4,819	200-42,300
D.O. (mg/l)	8.6	3.5-13.9	8.0	3.2-13.7	8.6	0-14.1	8.3	0.1-20	--	--	8.7	2.1-15.2	9.1	1.2-14.5	8.5	6.4-12.6	8.5	4.7-13.2
Alkalinity (mg/l as $CaCO_3$)	226	110-340	180	89-263	312	110-464	234	96-460	165	80-212	174	88-290	201	92-394	262	127-398	201	131-292
Ammonia (mg/l)	0.36	0.05-1.7	0.43	0.01-1.28	1.2	0.2-3.0	0.26	0.01-4.4	--	--	0.13	0.01-0.46	0.6	0.1-1.0	--	--	0.25	0.01-7.1
Arsenic (mg/l)	0.01	0.004-0.021	--	--	0.005	--	0.01	0.001-0.023	--	--	0.009	0.001-0.010	0.003	0-0.013	--	--	0.006	0-0.025
Barium (mg/l)	0.07	0.012-0.13	--	--	0.1	--	0.024	0.012-0.050	--	--	0.024	0.012-0.050	0.027	0-0.3	--	--	0.032	0.02-0.05
Beryllium (mg/l)	--	--	--	--	--	--	--	--	--	--	--	--	0	0	--	--	--	--
Boron (mg/l)	0.08	0.05-0.18	0.085	0-0.29	0.29	0-1.1	0.11	0.08-0.18	0.06	0-0.31	0.047	0.02-0.07	0.091	0-0.46	0.58	0.04-1.8	0.05	0.01-0.07
Bicarbonates (mg/l)	--	--	219	109-321	379	134-566	--	--	198	98-258	--	--	245	112-480	318	155-485	244	160-356
Cadmium (mg/l)	0.01	0.01-0.02	--	--	0.002	--	0.01	0.01-0.012	--	--	0.013	0.01-0.21	0.0005	0-0.007	--	--	0.008	0-0.010
Chlorine (mg/l)	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Chloride (mg/l)	20	5-54	11.2	4-23	80	8-310	19	1.5-120	2.9	0.5-5.8	4.8	0.5-18.0	9.0	0-29	634	120-1,810	18.9	5.1-130
Chromium (mg/l)	0.008	0.002-0.014	--	--	0.002	--	0.012	0.002-0.02	--	--	0.011	0.002-0.02	0	0	--	--	0.006	0-0.07
Chromium (+6)(mg/l)	0.007	0.002-0.010	--	--	--	--	0.013	0.01-0.02	--	--	0.013	0.01-0.02	0	0	--	--	0.013	0.01-0.02
Coliform (Total)(No/100 ml)	31,000	$80-2.4x10^6$	10,420	1,300-35,000	26,430	$10-1.1x10^6$	2,462	20-16,000	--	--	5,546	20-92,000	4,787	0-240,000	357	280-510	6,530	500-24,000
Coliform (Fecal)(No/100 ml)	1,131	20-33,000	4,456	790-17,000	2,905	1-110,000	152	20-4,900	--	--	943	20-23,000	725	0-44,000	165	32-380	432	1-2,000
Color (Units)	24	5-80	23	16-29	51	30-90	29	5-120	23	4-90	30	5-100	18	1-70	70	--	27	10-100
Copper (mg/l)	0.014	0.010-0.10	--	--	0.003	--	0.012	0.01-0.04	--	--	0.012	0.01-0.06	0.005	0-0.02	--	--	0.022	0.01-0.06
Cyanide (mg/l)	0.018	0.005-0.05	--	--	--	--	0.017	0.005-0.05	--	--	0.017	0.005-0.05	0.002	0.01-0.004	--	--	0.02	0.005-0.05
Gases	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Iron (mg/l)	2.71	0.02-18.0	0.045	0.02-0.09	0.86	0-5.6	1.8	0.04-18.0	0.54	0.01-2.1	1.29	0.01-17.0	0.019	0-0.1	0.009	0-0.08	2.6	0.16-19.0
Hardness (mg/l as $CaCO_3$)	288	160-410	231	120-333	621	190-930	300	140-530	191	100-298	202	130-300	254	126-836	715	270-1,200	237	170-360
Flouride (mg/l)	0.19	0.1-0.5	--	--	0.42	0-1.5	0.20	0.1-0.84	0.17	0-0.4	0.11	0.1-0.3	0.24	0-0.7	0.43	0.1-1.1	0.21	0-0.5
Lead (mg/l)	0.018	0.010-0.25	--	--	--	--	0.018	0.01-0.42	--	--	0.012	0.01-0.13	0.0007	0-0.005	--	--	0.09	0.012-0.10
Manganese (mg/l)	0.155	0.010-0.53	0.053	0-0.13	0.28	0.01-1.1	0.13	0.006-1.20	0.06	0-0.27	0.099	0.01-0.64	0.037	0-0.24	0.35	0-1.5	0.24	0.03-1.2
Mercury (mg/l)	0.0003	0.00001-0.0025	--	--	--	--	0.0004	0.0001-0.0025	--	--	0.0002	0.0001-0.0008	0.0004	0-0.0014	--	--	0.0004	0-0.0024
Nickel (mg/l)	0.013	0.010-0.050	--	--	--	--	0.011	0.01-0.024	--	--	0.011	0.01-0.049	0.006	0-0.013	--	--	0.011	0.01-0.02
Nitrates (mg/l)	--	--	4.8	0.1-18	3.7	0-12	0.5	0.02-4.7	0.2	0.02-1.4	0.23	0.01-2.5	3.8	0-37	3.7	0.7-9.7	1.0	0.02-33.0
Oil and Grease (mg/l)	0.48	0.3-1.0	--	--	--	--	0.6	0.3-1.2	--	--	0.44	0.3-0.6	--	--	--	--	0.35	0.3-0.5
Phenol (mg/l)	0.009	0.004-0.020	--	--	--	--	0.007	0.003-0.010	--	--	0.008	0.002-0.02	--	--	--	--	0.012	0.005-0.02
pH (Units)	7.9	7.1-9.0	7.8	7.1-8.9	7.8	7.3-8.4	8.0	7.0-8.9	7.8	6.9-8.7	7.9	6.8-9.0	7.7	7.0-8.7	7.7	7.2-8.3	7.8	7.2-8.7
Polychlorinated Biphenyl (mg/l)	--	--	--	--	--	--	--	--	--	--	--	--	0	0	--	--	0	0
Phosphates (mg/l)	0.51	0.01-1.9	0.45	0.39-0.51	0.81	0.01-2.8	0.41	0.07-4.9	0.10	0.01-0.57	0.18	0.01-2.8	0.12	0-0.27	--	--	0.30	0.08-1.5
Pathelate Ester (mg/l)	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Selenium (mg/l)	0.006	0.001-0.017	--	--	0.005	--	0.006	0.001-0.010	.01	--	0.006	0.001-0.01	0.007	0-0.023	--	--	0.002	0-0.012
Sodium (mg/l)	32	7-62	--	--	111	15-330	29	4-150	4.9	2.3-11.0	6.6	2.9-17.0	17	4.2-43.0	435	83-1,080	21.9	9.2-100
Silver (mg/l)	.004	0.002-0.010	--	--	--	--	0.005	0.002-0.01	--	--	0.004	0.002-0.01	0.0015	0-0.005	--	--	0.004	0.002-0.010
Sulphates (mg/l)	99	14-180	79	36-156	440	90-800	106	29-260	34	7-125	28	9-81	72	18-152	438	150-850	59	20-150
Temperature (C°)	10	0-25	9	0-28	10	0-26	7.5	0-24.5	7.3	0-26	7.3	0-23	8.8	0-26	10	0-25	9.9	0-26.5
Total Suspended Solids (mg/l)	129	1-1,100	--	--	--	--	77	0.5-750	--	--	49	1-410	--	--	--	--	84	46-98
Total Dissolved Solids (mg/l)	555	36-1,500	341	186-501	1,108	261-2,190	524	260-1,100	246	145-388	330	28-1,500	342	191-540	1,963	579-4,320	341	217-679
Zinc (mg/l)	0.04	0.01-0.49	--	--	.02	--	0.031	0.01-0.27	.09	--	0.062	0.01-2.8	0.01	0-0.046	--	--	0.046	0-22
Turbidity (JTU)	64	3-320	17	3-110	9	2-14	64	2-1,500	--	--	66	2-4,500	15	3-56	2	--	31	3-200

[1] All data are for the periods when samples were taken. The number of samples varies significantly.
[2] From Storet Data Summary 11/2/76 for Minnesota Station RE-403, Period of Record 1967-1976.
[3] From Storet Data Summary 7/19/77 for North Dakota Station 50645, Period of Record 1961-1977.
[4] From Storet Data Summary 7/19/77 for North Dakota Station 50665. Period of Record 1969-1977.
[5] From Storet Data Summary 7/19/77 for Minnesota Station RE-300. Period of Record 1953-1977.
[6] From Storet Data Summary 7/19/77 for Minnesota Station 50790. Period of Record 1962-1976.
[7] From Storet Data Summary 7/19/77 for Minnesota Station RL-0.2. Period of Record 1953-1977.
[8] From Storet Data Summary 7/19/77 for North Dakota Station 50825. Period of Record 1949-1977.
[9] From Storet Data Summary 7/19/77 for North Dakota Station 50830. Period of Record 1971-1975.
[10] From Storet Data Summary 7/19/77 for North Dakota Station 50835. Period of Record 1973-1977.

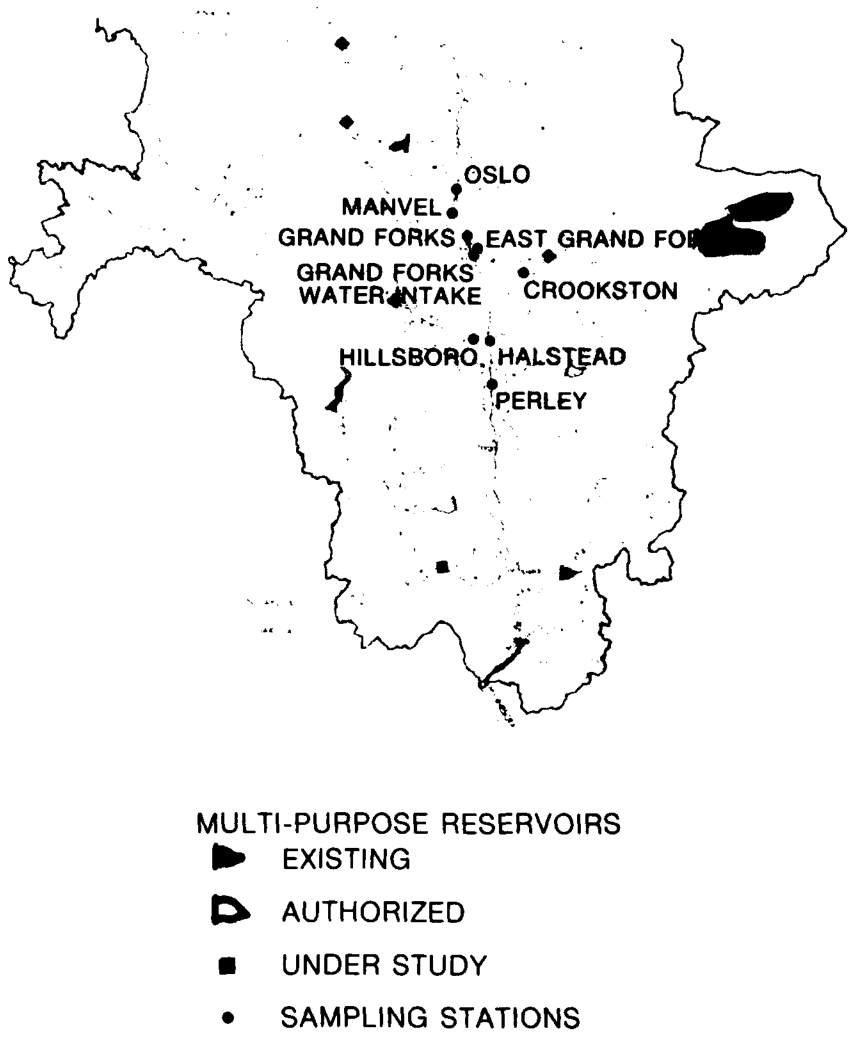


Figure 4 - Selected Sampling Stations - Red River Basin

Table 3 - Distribution analysis of water quality data

Indicator/Location	% of Values of Indicator Less Than Stated Value 10%	25%	50%	75%	90%
Turbidity (JTU)					
At Grand Forks[1]	3.5	7.5	27	50	72
At East Grand Forks[2]	3.5	6.0	16	32	45
Dissolved Oxygen (mg/l)					
At Grand Forks	6.0	7.0	8.6	10.0	12.1
At East Grand Forks	6.5	7.4	9.0	11.4	12.7
Ammonia Nitrogen (mg/l)					
At Grand Forks	<0.05	0.06	0.16	0.29	0.39
At East Grand Forks	<0.05	0.05	0.11	0.20	0.28
Fecal Coliform (No./100 ml)					
At Grand Forks	60	150	460	1,000	4,000
At East Grand Forks	30	60	240	760	2,200
Phosphates (mg/l as P)					
At Grand Forks	0.16	0.21	0.26	0.34	0.41
At East Grand Forks	0.05	0.08	0.13	0.20	0.30

NOTES: [1] Grand Forks Water Treatment Plant Intake - Statistics based on 56 samples taken from January 1969 to April 1974.

[2] East Grand Forks Water Treatment Plant Intake - Statistics based on 91 samples taken from January 1969 to May 1977.

Source: Stanley Consultants

Limited efforts were made to correlate selected indicators with flow at the Grand Forks gage No. 5-0825. Generally, total dissolved solids and hardness decrease with increasing flows. Color, dissolved nitrate,

nitrogen, and phosphorus tend to increase with increasing flows. The highest phosphorus value measured between October 1968 and September 1977 was 0.6 mg/l occurring at a river flow of 40,600 cfs. The highest nitrate nitrogen value was 18 mg/l NO_3 also at this flow. Typical values at flows between 500 and 3,000 cfs were 0.5 mg/l NO_3 and 0.15 mg/l phosphorus. Color also appears to increase with increasing flows, but high color (50 units) has occurred at flows less than 3,000 cfs.

GROUNDWATER RESOURCES

The study area soils are deposits of glacial Lake Agassiz, a silty clay extending in depths to 200 feet. The bedrock aquifers in the area are characterized by total dissolved solids exceeding 13,000 mg/l and hardness exceeding 3,000 mg/l. Total dissolved solids and hardness decrease as depth decreases.

Several glacial drift aquifers exist in the area (6). The glacial drift aquifers in the immediate vicinity of the urban areas are characterized by small to moderate yields and total dissolved solids levels exceeding 1,000 mg/l as are several artesian wells in Grand Forks County. At low streamflows when groundwater inflow is the major source of surface water runoff, streams in the area exhibit characteristics similar to groundwater.

Locations and physical and chemical characteristics of glacial drift aquifers in the study area are provided on figure 5 and in tables 4 and 5.

The low permeability of the Lake Agassiz soils has led to the construction of many artificial drainage channels. The slow drainage also impedes the use of septic tank and tile drain wastewater treatment systems for individual homes and commercial establishments.

Table 4 - Physical characteristics of aquifers

Name	Area (sq miles)	Depth Interval (ft)	Average Thickness (ft)	Estimated Storage (acre-ft)	Potential Yield (gpm)
Sand Bed	290	160 - 175	10	500,000	5 - 50
Beach Ridge	180	10 - 30	10	175,000	10 - 20
Fordville	28	5 - 55	20	100,000	50 - 500
Inkster	11	5 - 70	27	60,000	50 - 500
Elk Valley	200	5 - 75	34	1,300,000	50 - 500
Emerado	15	80 - 110	15	43,000	50 - 500
Grand Forks	20	175 - 215	18	69,000	50 - 250
Thompson	8	121 - 150	25	38,000	50 - 250

Source: Reference (7)

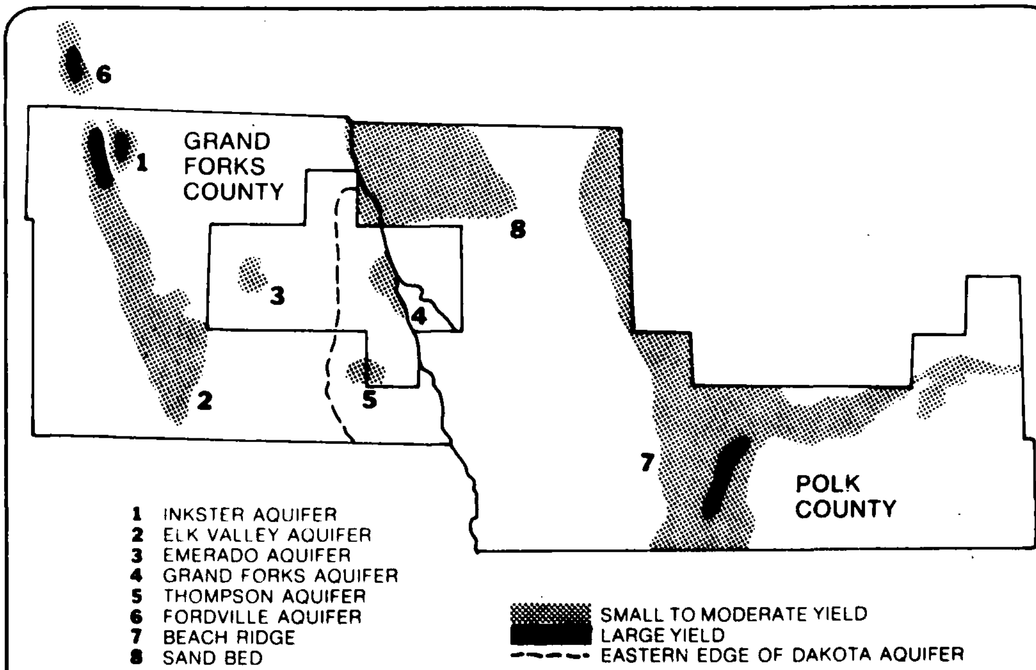


Figure 5 - Major Glacial Drift Aquifers and Yields of Wells
Grand Forks and Polk Counties

Table 5 - Representative chemical characteristics of aquifers

Aquifer	User	Depth (ft.)	Iron	Calcium	Magnesium	Sodium	Chloride	Potassium	Sulfate	Hardness	Total Dissolved Solids
			Concentrations (mg/1)								
Grand Forks	Test Hole in Grand Forks	31	4.4	378	213	95	101	8.4	1,530	3,310	2,740
Grand Forks	Pillsbury Co.	294	1.6	1,623	764	823	5,644	--	627	2,387	13,938
Thompson	Test Hole in Thompson	146	1.9	270	111	1,200	1,860	27	970	2,051	4,500
Emerado	Test Hole in Emerado	90	0.22	205	79	289	368	17	733	1,454	1,890
Inkster	Observation Well	74	0.24	79	21	6.5	2	2.8	71	350	306
Elk Valley	Test Hole Near Larimore	58	0.14	90	23	16	16	4.0	63	368	426
Elk Valley	Test Hole at HWY 2 & 18	60	0.12	90	31	19	11	--	86	418	391
Sand Bed	Unknown, Reported saline high total dissolved solids, probably similar to Grand Forks Aquifer.										
Beach Ridge	Unknown, Reported dissolved solids less than 500 mg/1.										
Fordville	Probably similar to Elk Valley quality.										

Source: Reference (6) and Stanley Consultants

POINT SOURCES OF WATER POLLUTION

GENERAL

The previous section reviewed the water resources of the study area and the present quality of groundwater and surface water in the study area. This section reviews point sources of water pollution in the study area. All wastewater treatment facilities in the study area are lagoons with controlled discharge. Typically wastewaters are stored during the winter and released in the spring at the time of high river flow. Normal discharge continues through the summer and fall.

REVIEW OF EXISTING WASTEWATER TREATMENT FACILITIES

Available information on the lagoons in the study area is summarized in table 6. The State of Minnesota uses the Ten State Standards (8) as guides on lagoon adequacy. These standards suggest one acre/100 population equivalent and a loading of 0.5 pound BOD_5 per 1,000 square feet of surface (21.8 pounds BOD_5/acre/day) for the primary lagoon in a series operation. Storage for 180 days of flow is to be provided between liquid depths of 2 and 5 feet to provide proper treatment and prevent the growth of aquatic weeds. Criteria used in North Dakota also include a liquid retention time of 180 days between the 2- and 5-foot depths and an organic loading of 30 pounds BOD_5/acre/day on primary cells. Other factors include requirements for three-cell series operation, 3:1 side-slopes on dikes, 3-foot freeboard above the 5-foot level, water depths of 5 feet, and center discharge (9). The discharge line and structure is sized to release accumulated wastewater in a certain number of days of discharge per year.

Available information summarized in table 6 indicates major facilities are meeting or exceeding required effluent criteria. Both the State of Minnesota (10) and the State of North Dakota (11) in their water quality modeling efforts have determined that the Red River of the North is an effluent limited stream segment which means that water quality standards will be met if effluent criteria for secondary treatment are met.

Table 6 - Point sources of water pollution in the study area

Treatment Facility	Built	Description	Design Basis[3] (Average) Flow (MGD)	Design Basis BOD$_5$ (mg/l)	Design Basis TSS (mg/l)	Raw Waste Characteristics[3] (Average) Flow (MGD)	Raw Waste BOD$_5$ (mg/l)	Raw Waste TSS (mg/l)	Final Effluent Characteristics[3] (Average) BOD$_5$ (mg/l)	Final Effluent TSS (mg/l)	Final Effluent F. Coli. (No./100 ml)	Effluent Standards (Average Monthly) BOD$_5$ (mg/l)	Effluent Standards TSS (mg/l)	Effluent Standards F. Coli. (No./100 ml)	Receiving Stream
East Grand Forks	1960	240-acre primary lagoon 95-acre secondary lagoon	1.1	512	---	0.731	---	---	11	17	100	25	30	200	Red River
Grand Forks	1960, 1968	4 cells @ 2.3-acre, 8.6 MG aerated lagoon pretreatment Two primary lagoons: 141-acre & 200-acre Two secondary lagoons: 145-acre & 146-acre	5.4	566	---	5.77	460	495	8	24	30	25	30	200	Red River
American Crystal Sugar	---	83-acre condensor pond 67-acre transport (mud) pond 10-acre lime pond	Recycle[1] Recycle[1] Holding	---	---	---	---	---	26	---	---	25 (No discharge if river flow <500 cfs.)	30	200	Red Lake River
Thompson	1966[2]	2.56-acre primary lagoon 1.95-acre secondary lagoon	0.027	---	---	0.035	---	---	---	---	---	25	30	200	Elm Coulee
Manvel	1973	2.95-acre primary lagoon 1.55-acre secondary lagoon	0.058	---	---	0.017	---	---	---	---	---	25 (No discharge if flow >5 x river flow)	30	200	Turtle River
Emerado	1962	2.54-acre primary lagoon 1.71-acre secondary lagoon	0.055	---	---	0.034	---	---	---	---	---	25	30	200	Salt Water Coulee
Grand Forks Air Force Base	1960 1972	Two primary lagoons: 78-acre & 60 acre One secondary lagoon: 35-acre	1.0	---	---	---	---	---	14	20	---	25	30	200	Kelly Slough

[1] Production water use (once-through basis) is 14.8 MGD, requirement to maintain water quality in recycle water is a 20 percent blowdown or about 3.0 MGD (1/2 transport, 1/2 condensor) of waste discharge. Discharge is made at high flow and effluent criteria must be met or no discharge is allowed.

[2] Proposals have been made to replace these lagoons in 1978 with new facilities.

[3] Based on city records and Reference (9)(10)(11)(14)(15).

Source: Stanley Consultants.

Additional information on the major treatment facilities in the study area is given below.

Grand Forks

The pretreatment and lagoon system at Grand Forks is providing an adequate degree of treatment, but the facilities are inadequate to meet State liquid retention time and organic loading criteria. Proposals to upgrade the facility have been made (9) (12). Studies completed for the city of Grand Forks under Section 201 of P.L. 92-500 indicate lagoon expansion and reconstruction of the effluent discharge line will resolve problems for the city through 1990 (12).

Currently, raw waste is directed to a pretreatment facility where approximately 50 percent BOD_5 reduction occurs (12). Current sources of raw waste loads to the lagoons based on city records are described in table 7.

Table 7 - Raw waste loads to Grand Forks lagoon[1]

Source	Average Values			Peak to Average Ratios		
	Flow (MGD)	BOD_5 (lb/day)	TSS (lb/day)	Flow	BOD_5	TSS
Bridgeman	0.045	505	160	2.11	2.04	3.24
International Co-op	1.34	9,900	9,610	2.61	3.08	6.05
Minnkota Power	0.03	100	10	---	---	---
N.D. State Mill	0.047	30	33	2.17	3.08	2.47
Pillsbury Company	0.44	2,628	4,908	1.33	2.87	3.31
U.N.D. Wilkerson Hall	0.018	310	125	---	---	---
U.N.D. Squires Hall	0.022	110	50	---	---	---
U.N.D. Center	0.021	170	115	---	---	---
U.N.D. Smith Hall	0.019	100	65	---	---	---
Roger's[2]	0.048	1,280	520	---	---	---
Total Industrial	2.03	14,333	15,596	---	---	---
Total City	6.22	24,060	25,960	1.13	1.76	2.89
Other City Sources[3]	4.19	9,727	10,364	---	---	---

[1]Based on city sampling data June 1976 to July 1977.

[2]Reported out of service.

[3]Residential and commercial.

Source: Stanley Consultants

Biological pretreatment facilities at Pillsbury and International Co-Op (13) provide a degree of organic and solids loading control on the city sewer system. International Co-op is planning to reduce current water use to about 0.8 MGD by in-plant recycling of effluent from their primary clarifier, aerated lagoon, final clarifier pretreatment facilities.

Historic effluent discharge from the lagoons compared to water use is provided on Figure 6.

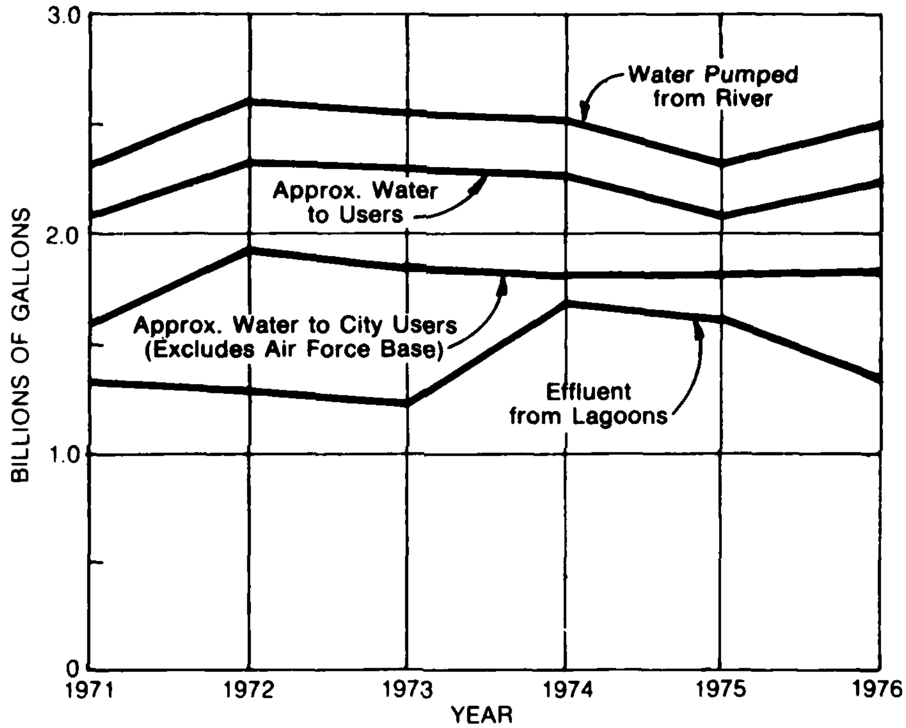


Figure 6 - Water Use vs. Wastewater Flow

On an average, approximately 78 percent of the water delivered to the city water users appears as lagoon effluent. The range is from 65

to 92 percent. The total discharge from the lagoons in any given year is a function of lagoon operation, evaporation from lagoons, water use and storage available, and treatment levels obtained. City water users have had a fairly consistent water use for the past few years.

The monthly discharge over the past few years is shown below. The city advises the North Dakota State Department of Health of impending discharge and commences discharge when the approval is given.

Discharge from Grand Forks lagoons

	Month											
	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
	Discharge (Million Gallons)											
1971	0	0	0	0	0	12	264	312	320	182	146	88
1972	0	0	0	0	190	204	182	198	190	180	132	---
1973	0	0	0	0	260	292	186	180	---	---	196	102
1974	0	0	0	0	272	224	320	68	232	216	208	144
1975	96	0	0	0	264	200	298	272	186	152	74	72
1976	0	0	0	0	0	232	192	184	---	300	296	148
1977	0	0	0	0								

The existing lagoons have a primary surface area of 341 acres, a secondary surface area of 291 acres, a storage volume of 618 MG and a total volume of 1,030 MG. Present city proposals (12) will provide 495 acres for primary, 834 acres for secondary, and a storage volume of 1,300 MG.

Alternative treatment concepts were evaluated and found to be less desirable for the city by itself (9) (12). The question of regional or areawide treatment systems for both Grand Forks and East Grand Forks has not been addressed (1).

East Grand Forks

The lagoon system at East Grand Forks has been judged adequate to meet existing and future (1983) standards of the Minnesota Pollution Control Agency (10). Similar to Grand Forks, the system faces wide swings in hydraulic and organic loading depending upon the operation of industries in the city.

Information on industrial waste loads to the lagoon is summarized below (14):

Industry	Flow (MGD)	BOD_5 (mg/l)	TSS (mg/l)	Comments
American Crystal	0.040	---	---	Sanitary only
Ryan Potatoes	0.012	60-900	500-8,000	Effluent from settling basin
Old Dutch Potatoes	0.020	---	50,000	---
King of Potatoes	0.050	---	50,000	---
Northern Potatoes	0.003	---	80,000	---
Water Treatment Plant	0.037	---	---	Filter backwash
City Total[1]	0.89	150-400	150-2,800	All city wastes

[1] 1975 data. Peak flow is 5,000 gpm, the capacity of the master lift station.

Water use and wastewater flow for 1976 are given below:

	Jan	Feb	Mar	Apr	May	June
Water Use (MGD)	1.14	1.21	1.15	0.95	1.18	1.22
Wastewater Flow (MGD)	0.54	0.65	0.98	1.01	0.69	0.68
Wastewater (Peak Flow/Average)	1.73	1.78	1.61	1.87	1.30	1.30

	July	Aug	Sept	Oct	Nov	Dec
Water Use (MGD)	1.43	1.33	1.25	1.15	1.12	1.10
Wastewater Flow (MGD)	0.57	0.52	0.48	0.50	0.54	0.59
Wastewater (Peak Flow/Average)	1.75	1.53	1.36	1.29	1.40	1.29

The effluent from the lagoons in 1975 ranged from 2 to 14 mg/l BOD_5, 6 to 21 mg/l TSS, 7 to 10 mg/l dissolved oxygen, and had fecal coliform values less than 10. Data for 1976 indicate an average annual flow of 0.63 MGD reflecting a drop in industrial flow with King of Spuds out of operation. Average flow in the processing season is about 1.0 MGD.

The existing lagoons have 240 acres of primary and 96 acres of secondary lagoon surface area. The design BOD_5 loading was 20 pounds BOD_5/acre/day (14) at a flow of 1.1 MGD. Storage volume is 389 MG. The primary lagoons were filling with solids, but a dredging program in 1976 has restored storage volume in the primary system. Problems do exist in shoreline erosion, as in Grand Forks, and require continuing shoreline protection measures.

The Americal Crystal Sugar Company in East Grand Forks operates its own wastewater treatment system. Treatment of its process wastewaters consists of fine screening followed by primary clarification. The overflow from the clarifier is recycled back to the plant to be used again. The underflow, containing the settled solids, is discharged to holding ponds. The system has been in operation about 5 years, and no discharge has been necessary from the holding ponds. The holding ponds are reaching their ultimate capacity, and discharge will be necessary in the near future. Discharge can occur if the pond contents meet the discharge criteria.

Grand Forks Air Force Base

The Air Force Base annual average wastewater flow is estimated at 1.13 MGD. The design basis flow of 1.0 MGD for the Air Force Base lagoons is based on a 180-day storage volume. Organic loading on the primary lagoons is well below 30 pounds BOD_5/acre/day (12 lb/acre/day at $Q = 1$ MGD and $BOD_5 = 200$ mg/l). The estimated average flow of 1.13 MGD does not affect treatment efficiency but does reduce storage capacity slightly. A waste treatment facility project in FY 1977 brought the base into full compliance with its NPDES permit, including oil collection from hangar and fueling area storm sewers (15). Adequate land is available for lagoon expansion as needs increase.

Thompson

The lagoons at Thompson were designed for a population of 417 and a flow of 0.027 MGD (11). The lagoon consists of a primary lagoon (2.56 acres surface area) and a secondary lagoon (1.95 acres surface area). Actual flow is 0.035 MGD. No discharge occurred in 1975 or 1976. The city is completing a Step 1 facilities planning effort. Results of this facility planning effort will define future needs for Thompson.

Manvel

The lagoons at Manvel were designed for a population of 557 and a flow of 0.038 MGD. The lagoons consist of a primary lagoon (2.95 acres surface area) and a secondary lagoon (1.55 acres surface area). Actual flow is 0.017 MGD. No discharge occurred in 1975 or 1976 due to evaporation. The lagoons do not meet three-cell design criteria of the State.

Emerado

The lagoons at Emerado were designed for a population of 549 and a flow of 0.036 MGD. The existing lagoons consist of a 2.54-acre primary cell and an 1.71-acre secondary cell. Current flow is 0.034 MGD. Three-cell design criteria are not met. No discharge occurred in 1975 or 1976. The treatment facilities were originally built with overflow manholes which allowed uncontrolled discharge of wastewater such that unrecorded discharges have occurred.

Other

Other small communities and rural subdivisions and rural residents rely on septic tanks and tile drain fields for wastewater treatment. Concentrations of residential development south of Grand Forks have overloaded the capacity of the soil in some areas.

REVIEW OF WASTEWATER COLLECTION FACILITIES

In Grand Forks and East Grand Forks, the sewerage system consists of collection sewers, sewage pumping stations, and wastewater treatment lagoons. The flat topography limits the use of gravity interceptors for wastewater collection. The collection systems will be extended to serve new growth areas. Some areas of the sewage collection systems are subject to infiltration and inflow, and detailed investigations are necessary to determine how much of this infiltration/inflow can be effectively controlled. A map of the existing major force mains and pumping stations is provided on figure 7. Information on the pumping stations is given in table 8.

The major source of inflow is the combined sewer area in Grand Forks, but studies and programs have been undertaken to eliminate this source (16). The major need is for completion of design investigations and the necessary construction funds to implement the program. Elimination of the combined sewer overflows will resolve the following problems in the study area:

1. Remove a primary source of organic loading and fecal coliform bacteria from the surface waters of the urban area.
2. Remove a primary cause of sewage back-up in basements with attendant public health hazards.
3. Remove wastewater flow and load to the lagoon system from stormwater runoff.

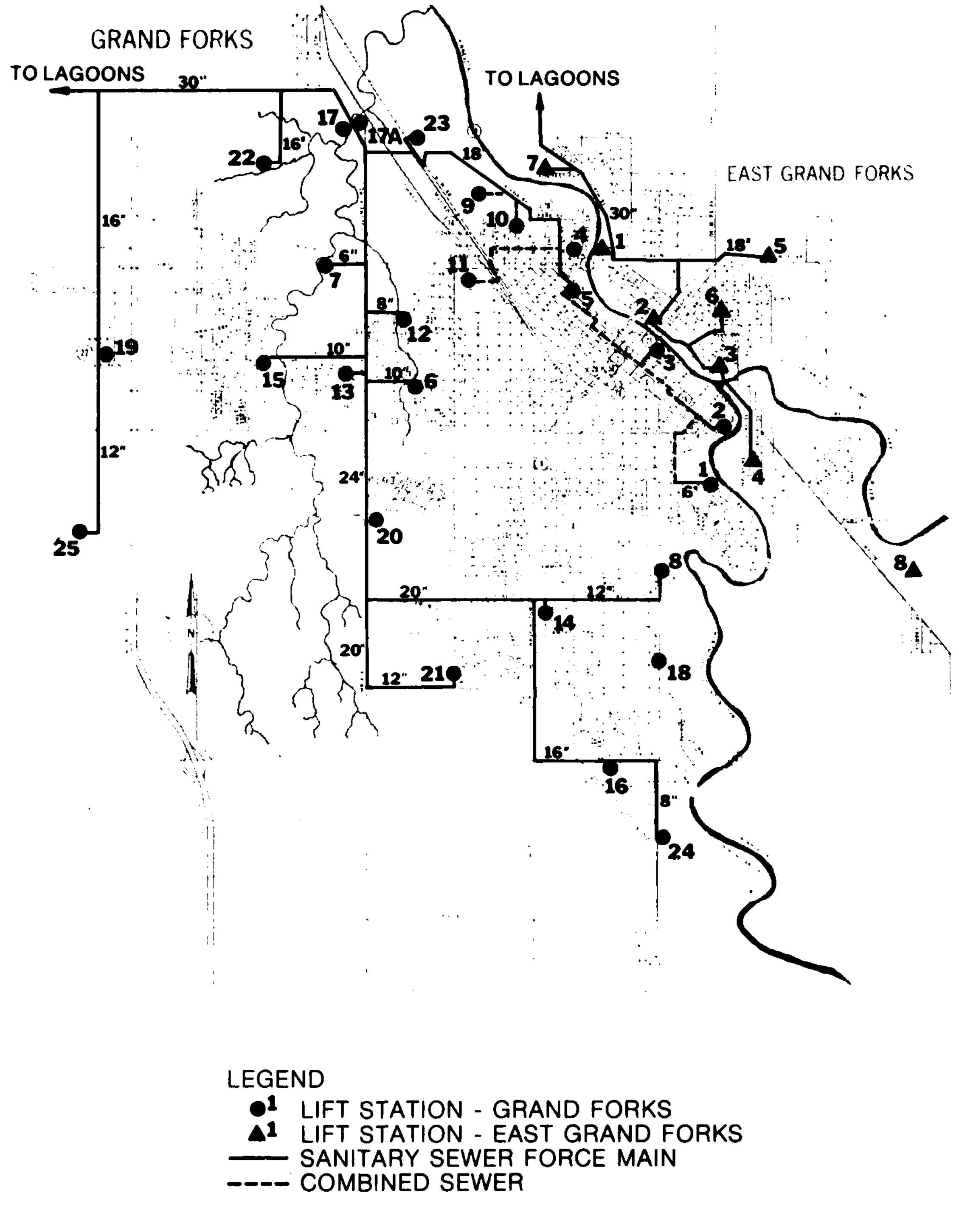


Figure 7 - Sewage Collection System, Grand Forks-East Grand Forks

Table 8 - Sanitary sewer lift station locations and capacities

	Lift No.	Location	No. of Pumps	HP Each	Capacity Each GPM @ Hd.	Capacity of Station
Grand Forks	1	101 Lincoln Drive	2	15	650 @ 50'	650
	2	301 Elm Avenue	2	5	200 @ 32'	200
	3	112 DeMers Avenue	2	15	800 @ 37'	800
	4	5 Fenton	2	7 1/2	120 @ 48'	120
	5	201 8th Avenue North	3	20	1,200 @ 37'	1,800
	6	321 North 23rd	2	10	800 @ 28'	800
	7	3010 Gateway Drive	2	9.4	300 @ 50'	300
	8	1435 Belmont Road	2	15	750 @ 43'	750
	9	Alpha Avenue	2	25	1,350 @ 33'	1,350
		Abandoned 1977				
	11	1809 13th Avenue North	2	1 1/2	200 @ 14'	200
	12	2421 10th Avenue North	2	5	400 @ 28'	400
	13	2811 6th Avenue North	2	5	500 @ 25'	500
	14	1731 South 12th Street	2	10	750 @ 33'	750
	15	3423 6th Avenue North	2	15	800 @ 40'	800
	16	625 32nd Avenue South	3	10	750 @ 35'	1,200
	17	2415 North Washington Street	3	100	4,000 @ 40'	7,600
	17.A	2415 North Washington Street	2	20	400 @ 58'	400
	18	2203 Belmont Road	1*	5	100 @ 20'	100
	19	4820 6th Avenue North	2	30	500 @ 72'	500
	20	1027 South Columbia Road	2	7 1/2	500 @ 36'	500
	21	2000 24th Avenue South	2	15	500 @ 47'	500
		Abandoned 1976				
	22	1921 North 36th Street	2	30	1,000 @ 59'	1,000
	23	2400 Mill Road	2	18	1,130 @ 29'	1,200
	24	3709 Belmont Road	2	5	230 @ 25'	230
	25	4900 11th Avenue South	2	40	1,000 @ 90'	1,000

*Pneumatic Efector

Source: City of Grand Forks

Table 8 - Sanitary sewer lift station locations and capacities (cont)

	Lift No.	No. of Pumps	Capacity of Pumps	Capacity of Station[1]
East Grand Forks	1	4	2 @ 3,300 gpm, 2 @ 2,000 gpm	5,000 gpm
	2	3	2 @ 1,000 gpm, 1 @ 500 gpm	1,200 gpm
	3	2	500 gpm each	700 gpm
	4	3	750 gpm each	1,200 gpm
	5	3	2,200 gpm each	4,000 gpm
	6	2	150 gpm each	150 gpm
	7	2	100 gpm	100 gpm
	8	2	265 gpm (Proposed)	265 gpm

[1]**Estimated**

Source: City of East Grand Forks

A major problem in the urban study area is the lack of auxiliary power at existing sewage lift stations. An extended electrical outage in the area could lead to severe public health problems in both cities.

Infiltration and inflow analysis is beyond the scope of this phase of the urban study program. The infiltration/inflow analysis report completed for the city of Grand Forks (16) indicates that infiltration was only 2 to 3 percent of the city's total wastewater flow and thus was not cost effective to eliminate. Inflow due to combined sewers was judged to be a major problem in the city. The sewer separation program of the city (17) was endorsed.

FORECAST OF WASTEWATER FLOW AND LOAD

Future flow and load forecasts at the wastewater treatment facilities in the study area need to be made to establish base criteria for use in judging whether the existing wastewater treatment facilities are adequate for future years. This section will forecast the no-action alternative flows and loads. Subsequent sections will analyze the impacts of the following on this base flow projection:

1. Reduction of wastewater flow and load by water conservation programs in the cities.
2. Reductions of wastewater flow and load by increased industrial pretreatment and water conservation and/or separate industrial waste treatment.
3. The impact of a major new wet industry on flow and load.

The projection methodology follows:

1. Population projections for the study area have been developed (18) and are shown in table 9. For areas where no additional information is available, future flows and loads are based on these projections. Future flow is taken as 100 gallons per capita per day and strength is based on a typical medium strength wastewater (19) as given in table 10.

Table 9 - Population projections for study area

	1975	1980	1990	2000	2010	2020	2030
Grand Forks	41,986	45,409	53,545	62,128	72,296	83,976	97,351
East Grand Forks	8,397	9,279	10,737	12,376	14,463	16,800	19,475
Air Force Base	10,700	10,700	10,700	10,700	10,700	10,700	10,700
Emerado	864	903	993	1,052	1,479	1,718	1,992
Manvel	263	263	263	263	263	263	263
Thompson	532	689	889	1,149	1,431	1,881	2,369
Rural	2,312	2,433	3,012	3,430	3,678	4,097	4,603
Total	65,054	69,676	80,139	91,098	104,310	119,435	136,753

Source: References (18)

Table 10 - Typical wastewater characteristics

Parameter	Concentration (mg/1)
Total Solids	700
Dissolved Solids	500
Suspended Solids	200
BOD_5	200
COD	500
Total Nitrogen	40
Organic Nitrogen	15
Ammonia Nitrogen	25
Total Phosphorus (as P)	10
Organic Phosphorus	3
Inorganic Phosphorus	7

Source: Reference (19)

2. Water demands for Grand Forks and East Grand Forks have been projected in a related study (20) and are provided in table 11.

The following assumptions and factors are used to convert these projected water demands to wastewater flow for the area for the no-action alternative.

a. No wastewater flow to Grand Forks and East Grand Forks systems would be introduced from process waters at the Air Force Base or at American Crystal Sugar as these facilities have their own waste treatment systems. (American Crystal Sugar does use the city system for sanitary and control lab wastes of 7,000 to 8,000 gallons per day.)

b. Future flow and load at Pillsbury and International Co-Op will be based on letters of intent values given below:

	Flow (MGD)	BOD_5 (lb/day)	TSS (lb/day)
Pillsbury	0.358	1,400	950
International Co-Op	0.800	6,000	10,000

All other industrial water use will represent a load on the systems. The strength of the composite industrial wastes is estimated to be 780 mg/l BOD_5 and 330 mg/l TSS which is the approximate strength of composite loads of miscellaneous industrial loads experienced at Grand Forks as derived from table 7.

c. Ninety percent of city residential and other commercial water use will become typical domestic wastewater. Because of the lack of specific monitoring information on the characteristics of the separate domestic wastewaters for Grand Forks and East Grand Forks, domestic wastewater characteristics used for load projections are based on a typical medium strength wastewater as given in table 10.

This estimate does not include 1.25 MGD for a new potato industry which was included in water demand projections for the city (21)(22). The projection method used here provides

Table 11 - Projected water demands

	1976 Annual Average (MGD)	Design Flow (MGD) 1976	1980	1990	2000	2010	2020	2030
Self-Supplied								
American Crystal	0.45	1.67	1.67	1.67	1.67	1.67	1.67	1.67
Burlington Industrial	0.18	0.32	0.32	0.32	0.32	0.32	0.32	0.32
Pillsbury	0.15	0.21	0.21	0.21	0.21	0.21	0.21	0.21
City Supplied Users								
Grand Forks								
G. F. Air Force Base	1.13	1.13	1.13	1.13	1.13	1.13	1.13	1.13
International Co-op	0.58	0.80	0.80	0.80	0.80	0.80	0.80	0.80
Pillsbury (city)	0.12	0.21	0.21	0.21	0.21	0.21	0.21	0.21
University of N. Dakota	0.19	0.29	0.29	0.29	0.29	0.29	0.29	0.29
Bridgeman	0.03	0.05	0.05	0.05	0.05	0.05	0.05	0.05
State Mill	0.04	0.05	0.06	0.06	0.06	0.06	0.06	0.06
Great Northern	0.05	0.07	0.07	0.07	0.07	0.07	0.07	0.07
United Hospital	0.06	0.12	0.12	0.12	0.12	0.12	0.12	0.12
Other Industry	---	---	0.10	0.21	0.50	0.75	1.00	1.25
East Grand Forks								
American Crystal	0.27	0.73	0.75	0.75	0.75	0.75	0.75	0.75
Ryan Potato	0.02	0.03	0.05	0.05	0.05	0.05	0.05	0.05
Burlington Industrial	0.15	0.30	0.30	0.30	0.30	0.30	0.30	0.30
Other Industry	---	---	0.20	0.30	0.40	0.50	0.60	0.70
City Residential & Commercial (Average Annual)								
East Grand Forks	0.73	0.84	0.93	1.07	1.24	1.45	1.68	1.95
Grand Forks	4.26	4.20	4.54	5.35	6.21	7.23	8.40	9.74
Average Total City Demand								
Grand Forks	6.46	6.92	7.37	8.29	9.44	10.71	12.13	13.72
East Grand Forks	1.17	1.90	2.23	2.47	2.74	3.05	3.38	3.75

Source: Stanley Consultants

values comparable to the estimates used by the city of Grand Forks for total waste loads (12), but some differences occur for specific industrial demands.

Considering the above factors, future wastewater flow and load for the cities of Grand Forks and East Grand Forks that must be handled by their wastewater treatment facilities is given in table 12. Values represent a significant reduction in flow and load over current values as a result of industrial flow and load reduction programs.

3. The characteristics for other parameters for industrial loads on the Grand Forks and East Grand Forks lagoons will be assumed to be as shown below. These values are based on average values in 1972 and 1973 when potato industries were operating in Grand Forks (23).

Projected industrial waste characteristics

Parameter	Concentration (mg/l)
Total Solids	1,875
COD	980
Total Nitrogen (as N)	54
Ammonia Nitrogen	24
Total Phosphorus	19
Inorganic Phosphorus	13

Source: Adapted from Reference (23).

IMPACT OF POINT SOURCES ON WATER QUALITY

The impact of point discharges on surface waters has been analyzed by various investigators and a number of mathematical models have been developed to describe the phenomenon (24).

Water quality data which show that certain indicators approach or exceed water quality standards will direct which indicators to model. The availability of information and funds to collect new information will determine the sophistication of water quality modeling efforts (25).

Table 12 - Projected wastewater flow and load
Grand Forks-East Grand Forks

	1976	1980	1990	2000	2010	2020	2030
Grand Forks							
Domestic							
Flow (MGD)	3.78	4.10	4.82	5.55	6.51	7.56	8.77
BOD_5 (lb/day)	6,300	6,840	8,040	9,260	10,860	12,610	14,630
TSS (lb/day)	6,300	6,840	8,040	9,260	10,860	12,610	14,630
Industrial							
Flow (MGD)	1.59	1.70	1.81	2.10	2.35	2.60	2.85
BOD_5 (lb/day)	10,210	10,930	11,640	13,530	15,150	16,790	18,400
TSS (lb/day)	12,140	12,440	12,750	13,540	14,230	14,900	15,600
Total							
Flow (MGD)	5.37	5.80	6.43	7.65	8.86	10.16	11.62
BOD_5 (lb/day)	16,510	17,770	19,680	22,790	26,010	29,400	33,030
TSS (lb/day)	18,440	19,280	20,790	22,800	25,090	27,510	30,230
East Grand Forks							
Domestic							
Flow (MGD)	0.76	0.84	0.96	1.12	1.31	1.51	1.76
BOD_5 (lb/day)	1,270	1,400	1,600	1,870	2,180	2,520	2,940
TSS (lb/day)	1,270	1,400	1,600	1,870	2,180	2,520	2,940
Industrial							
Flow (MGD)	0.62	0.87	0.97	1.07	1.17	1.27	1.37
BOD_5 (lb/day)	2,530	4,220	4,990	5,750	6,520	7,290	8,060
TSS (lb/day)	2,530	4,220	4,990	5,750	6,520	7,290	8,060
Total							
Flow (MGD)	1.38	1.71	1.93	2.19	2.48	2.78	3.13
BOD_5 (lb/day)	3,800	5,620	6,590	7,620	8,700	9,810	11,000
TSS (lb/day)	3,800	5,620	6,590	7,620	8,700	9,810	11,000

Source: Stanley Consultants

For point source discharges at low flow, a steady-state model of dissolved oxygen and mass balance determination of conservative pollutant concentrations usually are adequate to predict the impact of point sources on water quality.

The mass balance equation is:

$$C = \frac{\sum_{i=1}^{N} C_i Q_i}{\sum_{i=1}^{N} Q_i}$$

C = concentration of pollutants
Q = flow or discharge
i = point of discharge or stream

This equation will determine the concentration in a stream, after mixing, of a point source discharge. If the pollutant is conservative, it will not change until new pollutants are added downstream.

For nonconservative pollutants, models become more complex. The most generally modeled constituent is dissolved oxygen.

The dissolved oxygen level in a stream is a function of many variables - waste load, waste decay rates, photosynthesis, benthic demands, reaeration, etc. One model that has been used successfully in waste load allocation work (26) is described below. It is a steady-state, one dimensional simulation of the river DO, carbonaceous BOD, and ammonia concentrations. Photosynthetic effects and benthal demands are not included.

The equations used are as follows:

$$D(t) = \frac{K_1 L_0}{K_2 - K_1}\left(e^{-K_1 t} - e^{-K_2 t}\right) + \frac{K_N N_0}{K_2 - K_n}\left(e^{-K_N t} - e^{-K_2 t}\right) + D_0 e^{-K_2 t}$$

$$L(t) = L_0 e^{-K_1 t}$$

$$N(t) = N_0 e^{-K_N t}$$

Where: D(t) = DO deficit at time t

L(t) = Ultimate carbonaceous BOD at time t

N(t) = Nitrogenous BOD at time t, where nitrogenous BOD = 4.5 x NH_3-N

D_0 = Initial DO deficit

L_0 = Initial ultimate carbonaceous BOD

N_0 = Initial nitrogenous BOD

K_1 = Carbonaceous deoxygenation rate constant

K_N = Nitrogenous deoxygenation rate constant

K_2 = Reaeration rate constant

Various procedures and methods are used to determine the rate constants in the equations (27). This model is useful to analyze the impact of point sources on water quality where stream flows are low and where there is no overland flow runoff to the stream system. In general, efforts should be expended toward collection of more accurate information on the rivers to be modeled prior to undertaking efforts directed toward development or application of more sophisticated mathematical models that are available (24).

The impact of point sources on water quality has been evaluated in Water Quality Management Plans in both States (10) (11). The North Dakota study has evaluated impacts using river velocity of 0.4 ft/sec, depth of 3.8 feet, and temperature of 18° C. Values used in the equations were:

Effluent BOD_5 = 25 mg/l

Effluent NH_3-N = 5.5 mg/l

K_1 = 0.35/day

K_N = 0.3/day

K_2 = 0.7 - 1.0/day (0 if ice cover)

The analysis indicated that if discharge under ice were prohibited, there would be no low dissolved oxygen in the Red River in winter conditions. No dissolved oxygen problems would occur in the summer with facilities producing the above effluent water quality if river flow at the Grand Forks gage were greater than 300 cfs. Controlled discharge would allow water quality standards to be met.

NONPOINT AND INTERMITTENT POINT SOURCES

GENERAL

This section addresses in a general manner the quantity of materials that can potentially be added to surface waters by urban nonpoint and intermittent point sources. The impact of and measures to control rural nonpoint sources of pollution are being addressed separately by each State in ongoing 208 Water Quality Management Planning Efforts (28) (29).

Assessment of urban runoff impacts on water quality in this study area is difficult as essentially no information is available to quantify flows or loads to streams from the urban areas during rainfall-runoff events or snowmelt periods.

INTERMITTENT POINT SOURCES

Intermittent point sources in the major cities of the study area consist of combined sewer overflows in Grand Forks, sewage lift station overflows in Grand Forks and East Grand Forks, and storm sewer discharges in each city. Water reaches surface waters from these sources as a result of snowmelt, precipitation runoff, and occasional overflows due to inoperative lift stations. Possible known points of waste discharges are identified on figure 8.

To obtain a relative idea of the potential contribution of combined sewer, storm sewer, and overland flow urban runoff, a map was prepared showing the extent of urban development served by sanitary sewers, areas within this served by combined sewers, and areas served by storm sewers. This delineation is shown on figure 9. Approximate areas for each city are given in table 13.

Storm Sewers

With the completion of the phase I area of the Grand Forks combined sewer separation program, about 4.35 square miles in Grand Forks will be served by storm sewers (about 0.15 square mile in the Urban Renewal area has been separated). About 1.55 square miles will drain to the English Coulee and about 2.80 square miles will drain to the Red

Table 13 - Urban drainage - estimated existing area served

	Grand Forks	East Grand Forks
Developed Area Served by Sanitary Sewers	12.40 sq. mi.	3.55 sq. mi.
Developed Area Served by Combined Sewers	2.65[2] sq. mi.	0 sq. mi.
Developed Area Served by Storm Sewers[1]	3.05 sq. mi.	1.90 sq. mi.
Developed Area With Overland Surface Runoff	6.70 sq. mi.	1.65 sq. mi.

[1] About half drains to Red River, half to English Coulee in Grand Forks. About two-thirds drains to Red River, one-third to Red Lake in East Grand Forks.

[2] Phase 1 of Grand Forks Combined Sewer Separation Program (17) will remove about half of this value to area served by storm sewers.

Source: Stanley Consultants

River of the North. About 1.90 square miles of urban area is served by storm sewers in East Grand Forks.

Combined Sewers

Approximately 1.35 square miles of urban area or about 8 percent of developed urban area served by sanitary sewers will be served by combined sewers after phase I of the sewer separation program is completed. These combined sewers deliver sanitary wastes to lift stations in dry weather and transport both storm runoff and sanitary wastes in rainfall-runoff or snowmelt periods. All known combined sewers are in Grand Forks.

Overflow at Lift Stations

Precipitation events can lead to infiltration and inflow in the sewerage systems of Grand Forks and East Grand Forks. Excessive infiltration/inflow can lead to overflows at a lift station when the station's capacity is exceeded. Discussions with city personnel indicate that this rarely occurs in East Grand Forks or

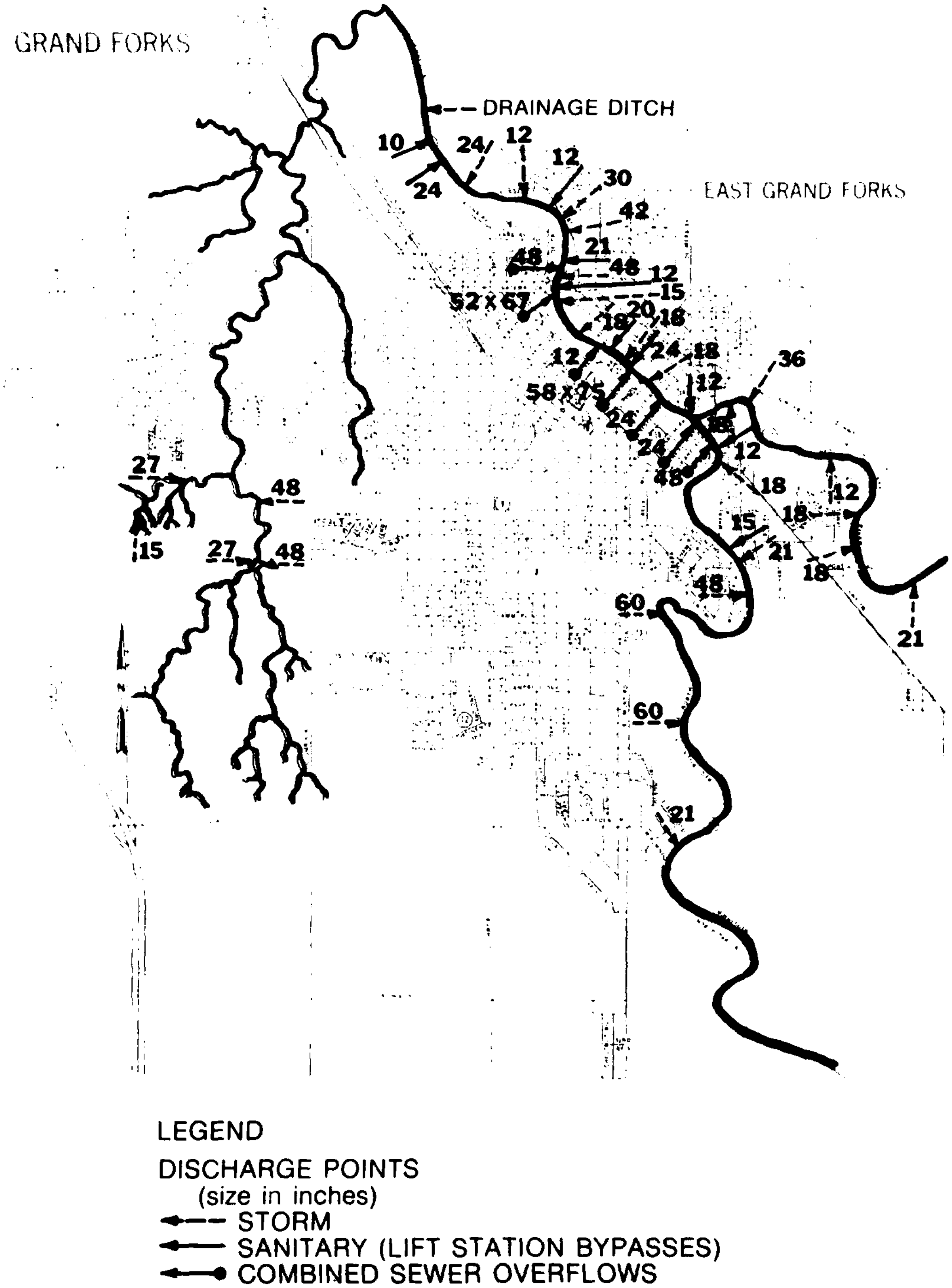


Figure 8 - Intermittent Point Sources of Pollution

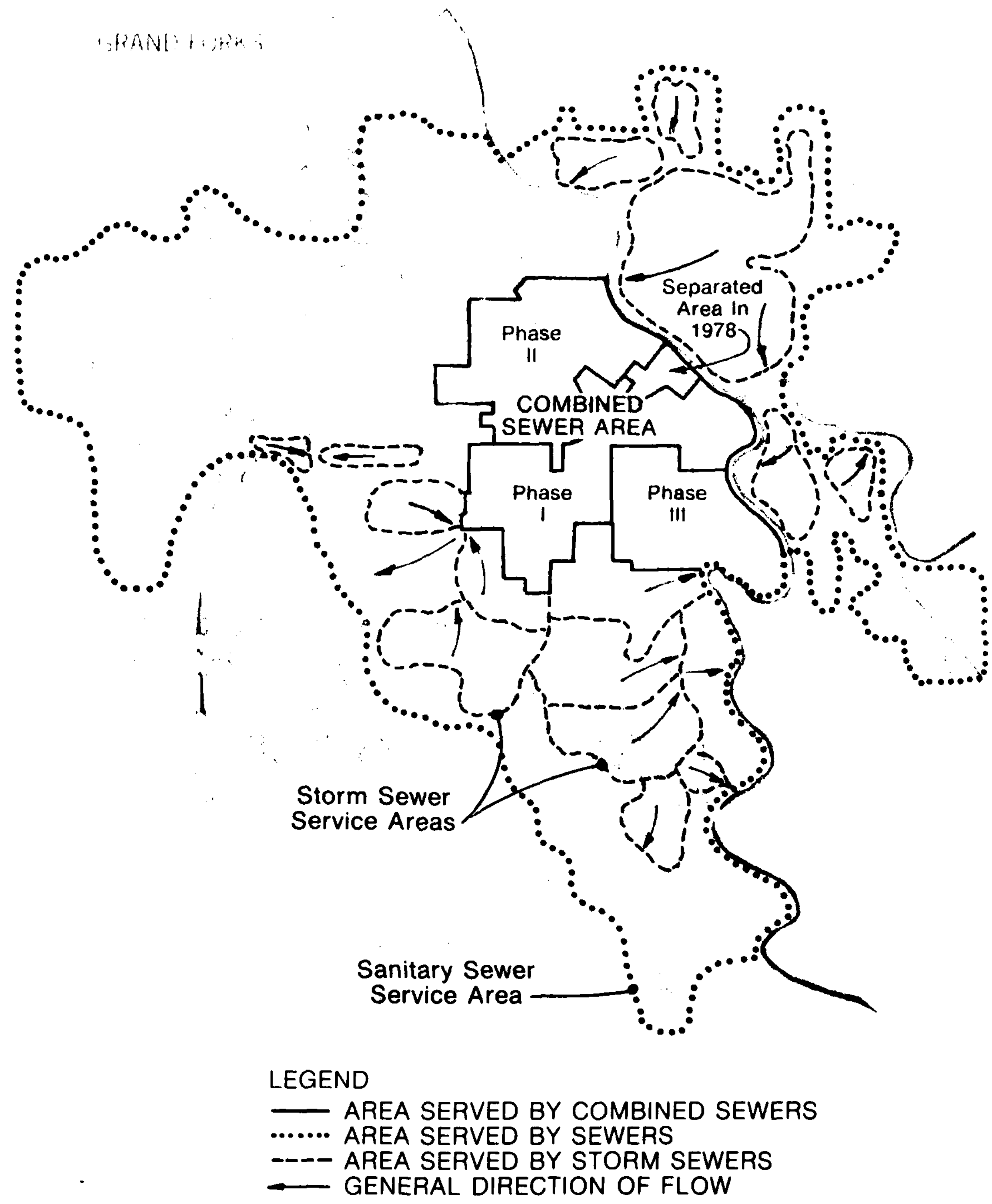


Figure 9 - Sewerage and Drainage in Urban Study Area

Grand Forks outside of the combined sewer service area. None of the lift stations in either city have auxiliary power supplies and a power outage can lead to overflows. This has occurred in both cities. Outages have lasted from 3 to 6 hours. Auxiliary power units have been recommended for Grand Forks (12). Because of the infrequent nature of power outages no estimates of flows or loads involved during these periods can be made. Extended power outages in the city could lead to severe public health problems from sewage backing up in the system. The Air Force Base has auxiliary power units to serve its needs (15).

URBAN NONPOINT RUNOFF

An additional 8.35 square miles of developed area, 6.7 square miles in Grand Forks and 1.65 square miles in East Grand Forks are drained by overland flow urban runoff. In these areas, runoff waters reach the major surface waters via road ditches, natural drainageways, and by infiltration and recharge. About two-thirds of the urban nonpoint runoff in Grand Forks reaches the Red River of the North via the English Coulee. Urban nonpoint runoff in East Grand Forks is about equally divided between the Red River of the North and the Red Lake River.

ESTIMATING URBAN RUNOFF FLOW

The "rational" method to predict peak stormwater flow is used by the cities and their consultants in the study area. Peak flow (Q) (cfs) is equal to a runoff coefficient (C) times a rainfall intensity (I) (inches/hr) times the drainage area (A) (acres) served. Thus, $Q = CIA$, the rational formula. An intensity-duration-frequency curve for the study area is shown on figure 10. Values used for frequency, I, and C by various entities in the study area are given in table 14. Peak flows estimated by this method are several times greater than average flow from a rainfall event. Assessment of an urban drainage system by more sophisticated methods such as the Storm Water Management Model (30) will yield more precise results than this simplified technique and provide an idea of flow variations with time.

Table 14 - Storm sewer design criteria

	Webster Foster Weston	KBM	Richmond Engineering	Floan-Sanders Inc.	City of Grand Forks	N.D. St. Hwy. Dept.
I	Varying	Varying	1.15	1.25	Varying	1.4
Return Period (yrs)	10	5	2 - 5	2	5	10
C	0.3 - 0.8	0.9 (Constant)	0.3 - 0.9	0.35 - 0.9	0.25 (Constant)	0.3 - 0.9

Source: City Engineering Department
Grand Forks, North Dakota

At this point in the urban study, however, only a relative idea of the impact of urban runoff on water quality is needed. For this reason, a simplified approach to estimating total volume of runoff is used. This total volume of runoff is then combined with the volume of river flow to predict total river flow downstream of the study area.

The total amount of rainfall is estimated closely by multiplying intensity by duration from figure 10. Results for various frequencies are given in table 15.

Table 15 - Rainfall volume at selected frequencies and durations

	Frequency		
Duration	2-Year	5-Year	10-Year
		Total Rainfall (Inches)	
30 minute	0.85	1.25	1.50
1 hour	1.00	1.45	1.75
2 hour	1.20	1.80	2.20
3 hour	1.20	1.80	2.20
4 hour	1.20	1.80	2.20

Source: Stanley Consultants

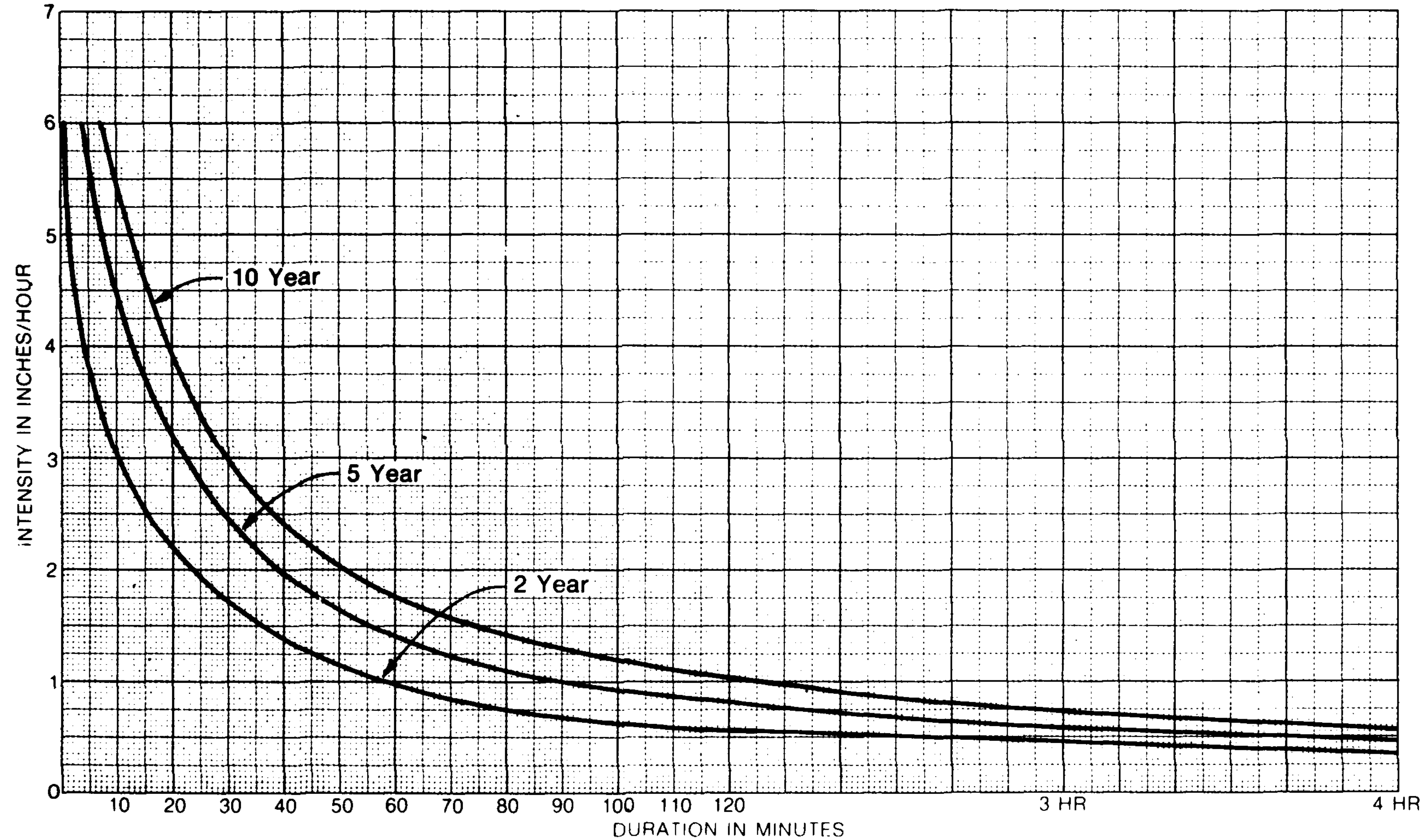


Figure 10 - Intensity - Duration - Frequency Chart
Devils Lake and Grand Forks

The amount of rainfall that will appear as runoff is dependent upon several variables. Simplified assumptions, considering runoff coefficient values used in the area, are as follows:

1. About 80 percent of the rainfall will run off in areas served by storm sewers.
2. About 25 percent of the rainfall will run off in urban areas not served by storm sewers.
3. About 10 percent of the rainfall will run off in rural areas (few streets and roads).
4. In areas served by combined sewers, the runoff will be about 80 percent of rainfall less the amount of stormwater delivered to wastewater treatment facilities.

The runoff continues after rainfall stops for some period of time depending on the characteristics of the drainage area. The greatest quantity of runoff in the shortest time using the above approach appears to be from a two-hour rainfall with a 10-year recurrence interval. Total rainfall from this storm would be 2.2 inches.

It is assumed that all runoff from this storm would occur at least in 24 hours. The total volume of runoff from the urban areas as a result of a storm of this magnitude is estimated as follows:

1. Runoff from urban areas served by storm sewers is equal to 80 percent of the 2.2 inches of rainfall times the area served.
2. Runoff from urban areas served by overland flow urban runoff is equal to 25 percent of the 2.2 inches of rainfall times the area served.
3. Runoff from combined sewer areas is estimated similar to storm sewer service areas except consideration is given to the wastewater flow and the amount of stormwater pumped to the lagoons.

It is estimated that the lift stations will transmit about 1,800 gpm from the combined sewer area in Grand Forks to the wastewater treatment lagoons. Assuming a population density of 15 people/acre and a per capita flow of 100 gallons/capita/day, a total of 1,370 gpm of wastewater will be discharged from the area. Therefore, about 430 gpm of stormwater will be delivered to the lagoons or about 0.62 MG in the assumed 24-hour runoff period. The remaining stormwater will overflow to the surface waters of the study area.

The estimated volume of runoff from this storm delivered to various surface waters by the urban areas is presented in table 16. The volume introduced by more frequent rainfall events (with less rainfall) would be in direct proportion to the amount of rainfall of the test storm using the simplistic assumptions in this section.

Table 16 - Runoff volumes in 24 hours from a 2-hour, 10-year frequency storm

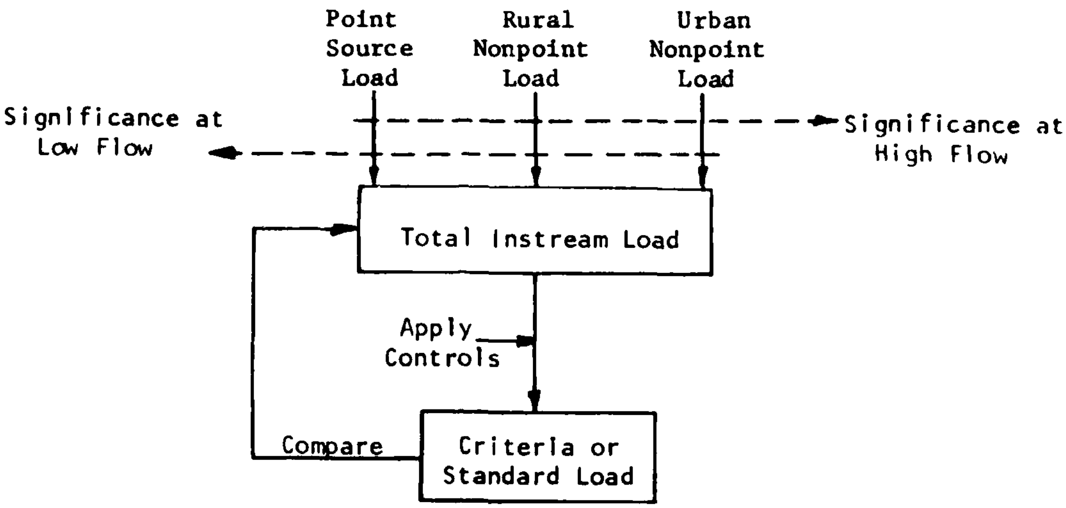
	Grand Forks		East Grand Forks	
Source	To Red River	To English Coulee	To Red River	To Red Lake River
Storm Sewers	86 MG	47 MG	39 MG	19 MG
Combined Sewer Overflow	62 MG	-	-	-
Urban Nonpoint	21 MG	43 MG	8 MG	8 MG
TOTAL	169 MG	90 MG	47 MG	27 MG

Source: Stanley Consultants

The total contribution of all sources will exist in the Red River of the North downstream of the confluence of the English Coulee. The flow in the Red River of the North at this point will depend on the flow of the Red Lake River and Red River of the North upstream of the study area and the rate of addition of stormwater runoff from the urban area and rural areas affected by the storm considered here.

ESTIMATING THE QUALITY OF URBAN RUNOFF

At higher streamflows, nonpoint sources of pollution become important. Analysis of high flow conditions involving overland flow runoff also becomes more complex. A concept model for analysis of high flow situations is shown below (31):



The total instream load can be calculated as follows:

$$L_T = Q_S C_S$$

The total nonpoint load can be calculated as follows:

$$L_{NP} = L_T - L_P$$

The total point load can be calculated as follows:

$$L_P = \sum_{i=1}^{n} Q_P C_P$$

The load added between two points can be calculated as:

$$L_T = Q_{S_1} C_{S_1} - Q_{S_2} C_{S_2}$$

Where: L = load   T = total
Q = flow   P = point
C = concentration   NP = nonpoint
S = instream

For urban nonpoint loads, a direct link between material loadings on the urban surface and deposition of materials in waterways following precipitation events has not been made. An extensive study (32) of available information has given general information on various water quality indicators in urban runoff as shown in table 17.

Table 17 - Generalized urban runoff quality

	Flow Weighted Mean Concentrations (mg/l)				
	BOD_5	TSS	TN	TP	Coliform (No./100 ml)
Combined sewer overflows	115	410	11	4	5×10^6
Bypassed sanitary waste to storm sewers	115	410	11	4	5×10^6
Surface runoff	30	630	3	1	4×10^5
Storm sewer discharges	30	630	3	1	4×10^5

Source: Reference (32)

Additional studies (33)(34) relate the amount of other indicators to the amount of solids. Average values of metals determined in analysis of street surface contaminants in 10 cities (33) are given in table 18.

Table 18 - Metals in urban runoff

Metal	lbs/100 lbs solids
Cadmium	8.4×10^{-7}
Chromium	7.9×10^{-3}
Copper	1.4×10^{-2}
Lead	4.1×10^{-2}
Mercury	5.2×10^{-3}
Nickel	3.6×10^{-3}
Zinc	4.6×10^{-2}

Source: Reference (33)

Studies completed in Tulsa, Oklahoma, (35) have been related to other studies (36) to indicate that about 30 percent of the solids on streets will reach waterways following a rainfall event.

The concentration of pollutants varies significantly during a runoff event. Often the initial runoff will be highly contaminated as the rainfall flushes materials from streets and resuspends deposits in storm sewers and combined sewers. Often peak pollutant concentrations will precede peak runoff flows, but in some instances (usually rural and urban nonpoint) peak concentrations will coincide with peak runoff flows (36).

Knowing the volume of runoff, assuming the above mean concentrations, and using data relating other indicators to the quantity of solids will allow a preliminary assessment of the loads introduced by an urban area. Continuous monitoring upstream and downstream of an urban area should also provide reliable data on the impact of urban runoff on water quality and certainly would be the preferred method considering the primitive state-of-the-art in nonpoint modeling. Limited water quality sampling is currently being undertaken in the area to assess the impact of combined sewer overflows on water quality. Results of this sampling program will be used to guide data collection and analysis programs in subsequent stage 3 work in the Grand Forks-East Grand Forks Urban Study.

IMPACT OF NONPOINT SOURCES ON WATER QUALITY

The total mass of materials added to surface waters can be estimated by the following procedure:

1. Total runoff volume from table 16 is multiplied by flow weighted mean average concentrations for BOD_5, TSS, TN, and TP from table 17.
2. Metal contributions are estimated by multiplying the resulting TSS load by the pounds of metal per 100 pounds solids

presented in table 18. Thirty percent of this value is assumed to represent the mass loading to the streams from solids suspended from streets in urban runoff.

These factors and assumptions have been applied to runoff volumes in table 16 and are presented in table 19.

Table 19 - Mass loadings to surface waters from urban runoff (2-hour, 10-year frequency storm)

Parameter	Combined Sewers	Storm Sewers	Urban Nonpoint	Total
Water (MG)	62	191	80	333
BOD_5 (lbs)	60,000	47,700	20,000	127,700
TSS (lbs)	212,000	1,004,000	420,000	1,636,000
Nitrogen (lbs)	5,700	4,800	2,000	12,500
Phosphorus (lbs)	2,100	1,560	670	4,330
Cadmium (lbs)	0.001	0.0025	0.001	0.0045
Chromium (lbs)	8.3	23.8	10.0	42.1
Copper (lbs)	14.7	42.2	18.0	74.9
Lead (lbs)	43.0	123.5	50.0	216.5
Mercury (lbs)	5.8	15.7	6.0	27.5
Nickel (lbs)	3.8	10.9	4.0	18.7
Zinc (lbs)	48	138.5	55.0	241.5

Source: Stanley Consultants

The amount of material added to surface waters by a 2-hour, 10-year frequency storm from the Grand Forks-East Grand Forks urban area has been estimated in this section using simplistic flow assumptions and literature values for the characteristics of that runoff. The overall intent is to provide some basis for determining whether urban runoff represents a water quality problem in the study area.

The estimated total urban source contribution of materials to surface waters from rainfall induced runoff is presented in table 20. Information from the Minnesota Pollution Control Agency for low-flow and average constituent concentrations in the Red Lake River and Red River of the North (37) is also presented. Finally, a mass balance determination of the likely concentrations of the various constituents downstream of the urban area when both streams are at the 7-day, 10-year low flow just prior to the rainfall event is presented in table 20.

The load analysis represents an extreme worst case type of condition. If rainfall and river flow are mutually exclusive, the probability of the 7-day, 10-year low flow and 10-year frequency storm occurring at the same time would be 1 in 100. Actual probability is more likely between 1 in 500 and 1 in 1,000. The test storm represents a sudden summer thunderstorm centered over the city at the time of low flow in the rivers in the study area. In actual conditions, additional river flow would likely be available from rural runoff which would lower the after-storm concentrations presented for the Red River of the North downstream of the study area. Figure 11 conceptually displays the probable actual change in river flow and concentration at the Oslo gaging station as a result of this storm and the average flow and concentration predicted here.

Unless the reaeration capacity of the river downstream of the study area is large, the predicted 40 mg/l BOD_5 load in the river may lead to low dissolved oxygen levels in the river. It is expected that urban runoff will lead to high total coliform levels in the rivers in much of the urban area as a result of combined sewer overflows. Analysis of other constituents indicates that on an average predicted lead, mercury, and phosphorus concentrations exceed water quality standards. Peak concentrations of other contaminants may approach or exceed numerical standards.

This analysis would indicate that a sampling program in which dissolved oxygen, BOD_5, TSS, TP, lead, mercury, and possibly ammonia

Table 20 - Total stormwater loads and river quality

Indicator[2].	Urban Stormwater	Red River at Grand Forks Water Intake (RE-300)	Red Lake River at East Grand Forks Water Intake (RL-0.2)	Red River Downstream of Study Area: Highest Value Recorded (RE-274)	Red River Downstream of Study Area: Predicted After Storm
Flow (MGD)	333.0	40.0[1]	12.0[1]	--	385.0
BOD_5	45.8	3.23	3.18	11.60	40.0
TSS	587	80	51	1,200	518.0
Nitrogen, Total	4.49	1.61	2.13	10.77	4.12
Phosphorus, Total	1.55	0.35	0.18	0.59	1.38
Cadmium	1.5×10^{-6}	0.010	0.013	0.038	0.0015
Chromium	0.015	0.012	0.011	0.020	0.014
Copper	0.027	0.012	0.012	0.042	0.025
Lead	0.078	0.018	0.013	0.140	0.070
Mercury	0.010	0.00037	0.00020	0.0015	0.0087
Nickel	0.007	0.011	0.011	0.020	0.0075
Zinc	0.087	0.032	0.064	1.00	0.081

[1]Represents 7-day, 10-year low flow from curves in Reference (38).

[2]Concentration mg/1 except as noted.

Source: Stanley Consultants

nitrogen were measured upstream and downstream of the study area and at representative sources in the study area before, during, and after a rainfall event would provide a good starting point to assess the impacts of urban stormwater runoff on water quality. Initial surveys in the study area are under way.

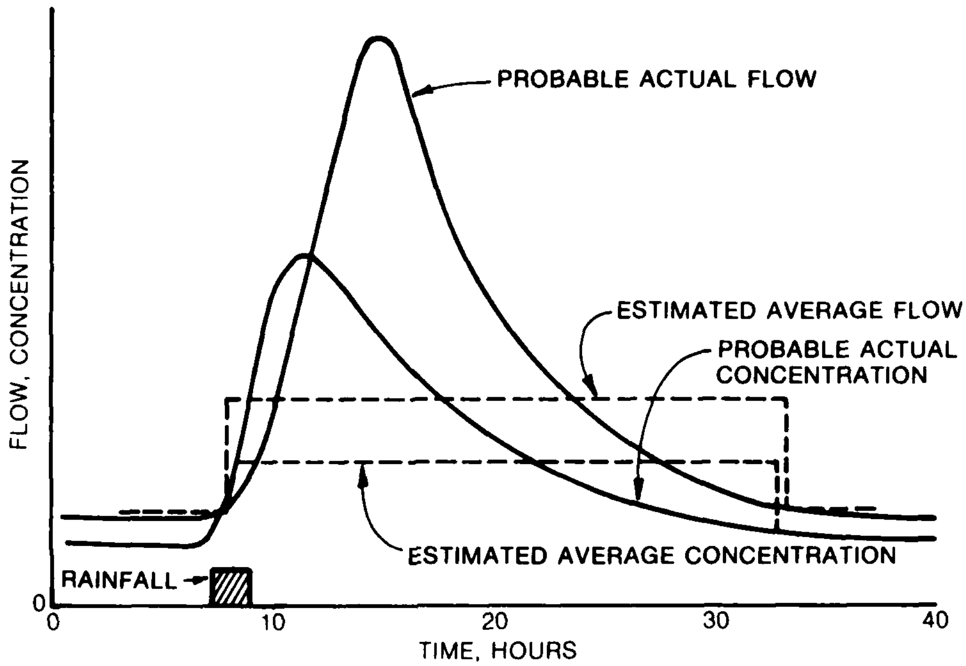


Figure 11 - Conceptual Response of the Red River of the North to the Test Storm Event

Two items will have to be considered in determining the degree of control required:

1. Rainfall itself is not pure and can add constituents to urban runoff which are generally beyond man's control.
2. Numerical water quality standards have usually been set considering adverse effects of long-term exposure on human and aquatic life. The short exposure of high concentrations that can occur in rainfall runoff may not present the same threat to man or aquatic life.

These investigations indicate that urban runoff and combined sewer overflows can potentially cause fecal coliform and dissolved oxygen violations for short periods following rainfall-runoff events of a 10-year frequency at low river flows. The predicted BOD_5 was 40 mg/l. Historic data (37) indicate a high measured BOD_5 of 11 mg/l. The prediction methodology may be valid as water quality sampling is seldom done during extensive rainfall events and the predicted BOD_5 of 40 mg/l represents a very low probability of occurrence event. A program of measuring various indicators from urban runoff and resulting stream water quality has been initiated and should provide more insight into the effects of urban loads on water quality for the study area. The 208 Water Quality Management Plans for Rural Nonpoint Sources being conducted by both States (28) (29) should provide more insight into the effects of rural loads and outline strategies to control those loads.

WATER QUALITY ASSESSMENT

GENERAL

A pollutant is a material introduced into a system which renders that system unfit for a specific purpose. Various Federal and State agencies have defined the purpose or desired uses of surface waters and have developed water quality standards to define the amount of materials that can be introduced or present in a surface water system without becoming pollutants. More limited attention has been given to setting quality standards for groundwater. Because of the complexity of natural water systems, various mathematical water quality models have been used in an attempt to predict the impact of materials introduced into a waterway. This section reviews water quality criteria and standards and effluent standards used for water quality analysis.

WATER QUALITY CRITERIA AND STANDARDS

A water quality standard is a plan established by government authority as a program for water pollution and abatement. Water quality criteria are scientific requirements on which a decision or judgment may be based concerning the suitability of water quality to support a designated use. A water quality standard for a particular water body (or segment) will generally consist of two elements: (a) a designated use and (b) criteria for various pollutants, expressed in numerical concentration limits, sufficient to support the designated use. The U.S. Environmental Protection Agency (U.S. EPA) has published water quality criteria (39) for various constituents. Both the State of North Dakota (40) and the State of Minnesota (41) have adopted water quality standards for designated uses based in part on those criteria as modified to take account of local conditions where organisms may have adapted to an otherwise adverse environment. Water quality standards have been developed for the use categories of Recreation and Aesthetics; Public Water Supplies; Fish, Other Aquatic Life, and Wildlife; Agricultural Uses; and Industrial Supplies. Minnesota is in the process of updating prior water quality standards (42). To violate these standards for any substantial length of time or in any

substantial portion of a waterway will result in an adverse effect on aquatic life and perhaps a hazard to man or other consumers of aquatic life (39). For certain constituents, an absolute numerical value cannot be established. In these cases, data obtained from a 96-hour bioassay of a sensitive aquatic organism using the receiving water as a diluent have been used. For the water uses reported herein, an LC_{50} is reported. This is the concentration introduced which causes 50 percent of the test species to die in the 96-hour test. Quality criteria for water (39) and existing water quality standards for North Dakota (40) and proposed standards for Minnesota (42) are presented in table 21. These values and values for additional constituents may change or be developed as additional knowledge is gained.

For many years, dissolved oxygen has been the most important water quality criterion for maintenance of aquatic ecosystems. The State of North Dakota has a water quality standard requiring dissolved oxygen to be greater than 5.0 mg/l in all surface waters at all flows greater than the statistically defined 7-day, 10-year low flow. The State of Minnesota (44) required 5.0 mg/l of dissolved oxygen or more for all conditions of river flow greater than the minimum monthly flow that is exceeded by 90 percent of the monthly flows of record for January and February. Certain industrial (agricultural processing) wastes discharged on a seasonal basis shall maintain 5.0 mg/l based on minimum monthly flow exceeded by 90 percent of the monthly flows of record for April or May and must maintain at least 3.0 mg/l at all river flows. The initial drafts of U.S. EPA water quality criteria (43) set numerical values for dissolved oxygen by relating minimum concentrations for selected levels of protection to the minimum concentration naturally occurring in the water (saturation value at highest stream temperature if not known or specifically determined for a river). Levels of protection were classified as nearly maximal, high, moderate, and low. Values and level of protection provided are given in table 22. The final report on water quality criteria sets a minimum value of 5.0 mg/l (39). Minnesota is developing new dissolved oxygen standards that are similar to the initially proposed Federal criteria (43) where a moderate degree of protection is proposed for the study area.

Table 21 - Water quality criteria and standards

Constituent	Water Quality Criteria[1] (39) Aquatic Life	Water Quality Criteria[1] (39) Water Supply	Minnesota[2] Standards (41)(42)	North Dakota[3] Standards (40)	Affect Being Controlled
Aesthetics	Free from materials that can form objectionable sludge deposits, floating debris, or scum, oil, color, odor, taste, turbidity, toxic materials, or rubbish which causes nuisance conconditions to exist or promotes development of nuisance aquatic life.				Unaesthetic water. Minimum requirements to avoid appearance of pollution.
Alkalinity (mg/l as $CaCO_3$)	>20	---	---	---	pH shock, human health
Ammonia (mg/l)	0.02 NH_3^+, total is function of pH and temp.	---	2.0 total (0.02 NH_3^+)	0.02 NH_3^+	Ammonia toxicity to fish
Arsenic (mg/l)	---	0.05	0.01 (0.01)	0.05	Arsenic poisoning
Barium (mg/l)	---	1.0	1.0 (1.0)	1.0	Toxic effect on heart
Beryllium (mg/l)	1.1 (hardness 150 mg/l)	---	---	---	Toxicity to fish and fish larvae
Boron (mg/l)	---	---	0.5	0.5	Toxicity to plants
Bicarbonates (mEq/l)	---	---	5	---	Iron deficiency in plants
Cadmium (mg/l)	0.012 (hardness 150 mg/l)	0.01	0.01 (0.01)	0.01	Toxicity to man and fish
Chlorine (mg/l)	0.01	---	--- (0.01)	0.01	Toxicity to fish and phytoplankton
Chloride (mg/l)	---	250	250 (250)	100	Taste of water
Chromium (mg/l)	0.1	0.05	1.0 (0.05)	0.05	Toxicity (most chromium is +6 at pH above 4.0)
Chromium (+6) (mg/l)	---	---	0.05	---	Toxicity
Coliform (total) No./100 ml	---	---	5,000	---	Transfer of disease
Coliform (fecal) No./100 ml	200 (30-day mean)	---	--- (200[4])	200 (May-Sept.)	Transfer of Disease
Carbon Chloroform Extract (mg/l)	---	---	0.2	---	Limit trace organics in water
Color (units)	---	75	--- (75)	---	To ensure color 15 with filtration
Copper (mg/l)	0.1 of LC_{50}-96 hr	1.0	0.2 (1.0)	0.05	Taste, toxicity to fish and larvae
Cyanide (mg/l)	0.005		0.02 (5 mg/l)	0.005	Toxicity to man, oxygen transfer to fish
Gases (total)	110% of saturation	---	---	---	The "Bends" and "Pop-Eye" in fish
Iron (mg/l)	1.0	0.3	0.3 (Soluble 0.3) (Total 1.0)	---	Taste, stains, toxicity to fish
Hardness (mg/l as $CaCO_3$)	---	---	500	---	Red[illegible]e deposits
Flouride (mg/l)	---	---	1.5 (1.5)	---	Mottling of teeth
Hydrogen Sulfide (mg/l)	0.002 H_2S^+	---	(0.002 H_2S^+)	---	

Table 21 - Water quality criteria and standards (cont)

Constituent	Water Quality Criteria[1] (39) Aquatic Life	Water Quality Criteria[1] (39) Water Supply	Minnesota[2] Standards (41)(42)	North Dakota[3] Standards (40)	Affect Being Controlled
Lead (mg/l)	0.01 of LC_{50}-96 hr	0.05	0.05 (0.05)	0.05	Toxicity, lead poisoning
Manganese (mg/l)	---	0.05	0.05 (0.05)	---	Taste, stains
Mercury (mg/l)	0.00005	0.002	--- (0.002)	0.002	Biomagnification, human toxicity
Nickel (mg/l)	0.01 of LC_{50}-96 hr	---	--- (0.01 x LC_{50}-96 hr)	---	Toxicity to plants and fish and crustacean reproduction
Nitrates (mg/l)	---	10	--- (10)	1.0	Infant methemoglobinemia
Oil and Grease (mg/l)	0.01 of LC_{50}-95 hr	None	10 (No visible)	---	
Pesticides (g/l)	0.003 Aldrin-Dieldren; 0.01 Chlordane; 100 2,4-D; 10 2,4,5-TP; 0.001 DDT; 0.1 Demeton; 0.003 Endosulfan; 0.01 Endrin; 0.01 Guthion; 0.001 Heptachlor; 0.01 Lindane; 0.1 Malathion; 0.03 Methoxychlor; 0.001 Mirex; 0.04 Parathion; 0.005 Toxaphene for aquatic life. 100 2,4-D; 10 2,4,5-TP; 0.2 Endrin; 4.0 Lindane; 100 Methoxychlor; and 5.0 Toxaphene for water supplies. Minnesota is adopting the water supply numbers.				Toxicity
Phenol (mg/l)	0.001	0.001	0.001 (0.001)	0.01	Fish flesh tainting, taste
pH (range)	6.5 - 9.0	5.0 - 9.0	6.0 - 9.0	7.0 - 8.5	Corrosion, toxicity
Polychlorinated Biphenyl (mg/l)	0.000001	---	--- (0.000001)	0.000001	Toxicity
Phosphates (mg/l)	0.1	---	---	0.1	Prevent algal growth
Pathalate Ester (mg/l)	0.003	---	--- (0.003)	---	Toxicity to fish
Radioactivity	(R_a 226 & 228: 5 pCi/l, Gross : 15 pCi/l, Tritium: 20,000 pCi/l, Strontium 90: 8 pCi/l)				Human health
Selenium (mg/l)	0.01 of LC_{50}-96 hr	0.01	Trace (0.01)	0.01	Toxicity to man and fish
Sodium	---	---	60% of cations as mEg/l	50% of cations as mEg/l	Toxicity to plants, taste
Silver (mg/l)	0.01 of LC_{50}-96 hr	0.05	0.05 (0.05)	---	Toxicity to man
Sulfates (mg/l)	---	250	250 (250)	250	Tastes, physiological affects
Temperature (° F)	Species Dependent	---	93°	85° (ΔT<5°)	Maintain aquatic life
Total Suspended Solids (mg/l)	25 for excellent fisheries, 25-80 for good to moderate fisheries, 80 poor fisheries				Prevent silt
Total Dissolved Solids (mg/l)	---	250	250 (500)	---	Taste, physiological affects
Turbidity	---	---	--- (25)	10	Aesthetics, suitability for use
Zinc	0.01 of LC_{50}-96 hr	5.0	1.0 (5.0)	1.0	Toxicity

NOTES: 1) Criteria for irrigation (0.1 mg/l arsenic, 0.5 mg/l beryllium, 0.75 mg/l boron, 0.1 mg/l nickel) and for marine life are also provided in this reference.

2) Regulations in existence (41) are followed by proposed revisions (42) in parentheses. These regulations are for Red River and Red Lake River which require water quality suitable for domestic consumption, fisheries and recreation, industrial consumption, agriculture and wildlife, and waste disposal. These standards apply at any river flow (41).

3) For Red River of the North, a Class I stream suitable for aquatic life, recreation, water supply, agriculture and wildlife, stock watering, and waste disposal. These standards apply at flows in excess of the 10-year, 7-day low flow level. The Turtle River in the study area is Class II and quality values are the same except 250 mg/l chloride, 0.1 mg/l copper, 1.5 mg/l nitrate nitrogen, 0.2 mg/l phosphate, and 2.0 mg/l zinc are substituted (40).

4) For nonfishable, nonswimmable waters less than 2,000/100 ml.

Table 22 - Dissolved oxygen water quality criteria

Protection	Type of Protection	Applications
Nearly Maximal (Minnesota Class A)	Unimpaired productivity Unchanged fishery quality	Conservation areas, parks, water bodies of unique value.
High (Minnesota Class B)	No appreciable harm to ecosystem. No material reduction of fish production.	Important fishery streams
Moderate (Minnesota Class C)	Fisheries will persist. Some decrease in production.	Fisheries of some value, but which must co-exist with industry or dense human population.
Low (Minnesota Class D)	Persistence of populations of tolerant species and passage of migrants. Reduction or elimination of sensitive species.	Appropriate for fisheries of some commercial or recreational value, but largely unimportant compared to other water uses.

Dissolved Oxygen Concentrations

Natural Minimum (mg/1)	Recommended Minimum For Selected Protection Levels (mg/1)			
	Near Maximal	High	Moderate	Low
5	5	4.7	4.2	4.0
6	6	5.6	4.8	4.0
7	7	6.4	5.3	4.0
8	8	7.1	5.8	4.3
9	9	7.7	6.2	4.5
10	10	8.2	6.5	4.6
12	12	8.9	6.8	4.8
14	14	9.3	6.8	4.9

Source: References (39) and (42).

These criteria and standards are used to measure surface water quality. The criteria proposed by the U.S. EPA were developed to respond to Section 101 (a)(2) of Public Law 92-500 which established as a goal that water quality should provide for the protection and propagation of fish, shellfish, and wildlife and provide for recreation in and on the water by 1 July 1983. These standards and criteria will determine, in part, the degree of treatment required at point sources and the degree of control of nonpoint sources necessary to achieve this national goal.

It should be pointed out that most numerical values are based on adverse effects observed over long-term exposure. Some regulatory authorities are now examining whether these same limits are valid at high flow conditions caused by precipitation runoff where values may only be exceeded for a period of hours or a few days. This will gain importance in analyzing the impact of nonpoint sources.

EFFLUENT STANDARDS

In addition to water quality standards, certain effluent limitations have been proposed on a national basis and adopted on a State basis under National or State Pollutant Discharge Elimination System permits. These permits specify the concentrations and/or total amount of materials that can be added to surface waters by point sources of pollution.

Municipal wastewater treatment facilities had until 1 July 1977 to achieve secondary treatment as defined by U.S. EPA. They also are to achieve Best Practicable Control Technology (BPT) by 1 July 1983 and to pursue as a goal no discharge of pollutants by 1985. Secondary treatment as defined by the EPA originally called for 85 percent removal of biochemical oxygen demand (BOD_5) and total suspended solids (TSS) or average monthly effluent concentrations of 30 mg/l BOD_5 and 30 mg/l TSS and required average monthly fecal coliform (F. Coli.) limits of 200/100 ml and pH within limits of 6.0 to 9.0. Concern over chlorinated hydrocarbons in the environment has resulted in the removal of fecal coliform limits. In addition, concern for the ability of waste stabilization

lagoons to economically meet the suspended solids limitations has resulted in a proposal to remove such limitations for facilities with a flow of less than 2.0 MGD. Current effluent limitations for Minnesota and North Dakota are given below (40)(41):

	BOD_5*	TSS*	F. Coli.	pH
North Dakota	25 mg/l	30 mg/l	200/100 ml	6.0-9.0
Minnesota	25 mg/l	30 mg/l	200/100 ml	6.5-8.5

*Or 85 percent removal if more stringent, Minnesota also specifies an effluent turbidity of 25 FTU. The Administrator of the Environmental Protection Agency has been authorized to amend the suspended solids limitations for lagoons if design flow is less than 2.0 MGD.

Effluent quality levels to meet best practicable treatment for municipalities and no-discharge criteria have not been finalized by U.S. EPA. Current thinking is that the effluent criteria for best practicable waste treatment will be that degree of treatment necessary to meet water quality standards. Minnesota may require 5 mg/l BOD_5 and 5 mg/l TSS in certain water quality limited stream segments.

The Corps of Engineers in Regulation ER 1105-2-180 has proposed criteria for use in urban studies in analyzing no-discharge effluent limitations. These criteria are:

$BOD_5 \leq 5$ mg/l	Total nitrogen $\leq$ 8 mg/l
TSS $\leq$ 5 mg/l	Nitrate Nitrogen $\leq$ 4 mg/l
Color $\leq$ 15 units	Ammonia Nitrogen $\leq$ 0.5 mg/l
Fecal Coliform $\leq$ 200/100 ml	Phosphate $\leq$ 0.1 mg/l to Streams
Oil and Grease = Trace	Total Dissolved Solids $\leq$ 500 mg/l
Dissolved Oxygen $\geq$ 5 mg/l	pH = 6.0-8.5

The concept of zero discharge via land application of wastewaters has been explored in various areas of the country.

The deadline for industrial facilities to achieve Best Practicable Control Technology (BPT) was 1 July 1977 and the Best Available Control Technology Economically Achievable (BAT) deadline is 1 July 1983.

Each industry has been analyzed and effluent limitations, typically based on pounds of pollutants per pound of production, have been established. New industrial facilities need to meet new source performance standards. Standards for industries important in the Grand Forks-East Grand Forks area are given in table 23. These values apply to limits that are to be obtained by direct discharge by the industry. Both Minnesota and North Dakota use Federal industrial effluent limitations in their permit programs.

In addition to standards for direct discharge, many industrial wastes are subject to pretreatment standards (46). When an industry uses a municipal facility to treat its waste, it is subject to industrial cost recovery regulations.

Table 23 - Effluent criteria for major industries in study area

Industry (Product)		BOD_5 (lb/1,000 lb Product) Max.	30-Day Avg.	Year Avg.	TSS (lb/1,000 lb Product) Max.	30-Day Avg.	Year Avg.	Other
Beet Sugar Processing (Refined Sugar)								
Barometric Condensor Only	BPT	3.3	2.2	---	---	---	---	T <90° F, pH 6-9
	BAT	2.0	1.3	---	---	---	---	T <90° F, pH 6-9
Condensor and Other Plant Waste	BPT	3.3	2.2	---	3.3	2.2	---	F. Coli <400/100 ml, T <90° F, pH 6-9
	BAT	2.0	1.3	---	2.0	1.3	---	F. Coli. <400/100 ml, T <90° F, pH 6-9
New Source Standards		Zero Discharge						
Potato Processing (Raw Material)								
Frozen Potato Products	BPT	2.8	1.4	---	2.8	1.4	---	pH 6-9
	BAT	0.34	0.17	---	1.1	0.55	---	pH 6-9
Dehydrated Potato Products	BPT	2.4	1.2	---	2.8	1.4	---	pH 6-9
	BAT	0.34	0.17	---	1.1	0.55	---	pH-6-9
New Source Standards		Same as BAT Standards						
Canned Products (Raw Material)								
Beets (all)	BPT	1.01	0.71	0.57	1.88	1.47	1.12	
<10,000 T/yr	BAT	0.682	0.548	0.361	1.242	0.852	0.722	
>10,000 T/yr	BAT	0.682	0.548	0.361	0.682	0.548	0.361	
Potato (all)	BPT	0.90	0.66	0.55	1.69	1.37	1.09	
<10,000 T/yr	BAT	0.572	0.476	0.342	1.09	0.803	0.707	
>10,000 T/yr	BAT	0.572	0.476	0.342	0.572	0.476	0.342	
New Source Standards		Same as BAT Standards for >10,000 T/yr Production						

Source: Based on 40 CFR 409, 40 CFR 407

WATER QUALITY AND WASTEWATER TREATMENT NEEDS

GENERAL

Prior sections have examined existing sources of water pollution in the urban study area, presented standards and criteria to judge the adequacy of these sources, and estimated the impact of these sources on surface water quality. The adequacy of existing facilities and systems to meet future needs of the study area is examined in this section.

SURFACE WATER QUALITY

The Federal Water Pollution Control Act Amendments (P.L. 92-500) set a national goal of achieving surface water quality suitable for fishing and swimming by 1 July 1983. The State of Minnesota has examined existing quality in the State in the low-flow period of 1 October 1975 to 30 September 1976 and related the quality found to the achievement of the national goal using selected State water quality standards as the evaluation criteria (44). Results of that analysis are presented in table 24. It is seen that turbidity and fecal coliform criteria are prime water quality problems in the rivers. The cause of these problems may be natural (high turbidity due to the fine silty clay nature of the stream beds) or man-made (high fecal coliform due to agricultural runoff, inadequately treated point sources, other diffuse sources) (10) (11). The major source of fecal coliforms in the study area is the combined sewer overflows in Grand Forks. The major source of added turbidity in the study area is urban stormwater runoff. These sources may be relatively minor when compared to rural nonpoint runoff contributions from upstream sources.

Surface water quality data were summarized in table 2. Water quality standards and criteria were given in the previous section. Table 25 indicates parameters which exceed standards. A review of the information

Table 24 - Adequacy of surface water quality

	Fishable Criteria[1]						Swimmable[1]
	DO	Turbidity	Ammonia	pH	Copper	Temp.	F. Coli.
Upstream of Study Area	100	50-90	100	90-100	100	100	50-90
Red Lake River in Study Area	100	50-90	100	90-100	100	100	less than 50
Red River in Study Area	100	50-90	100	90-100	100	100	50-90
Downstream of Study Area	100	50-90	100	90-100	100	100	less than 50

[1]Percent of samples meeting water quality standards.

Source: Reference (32)

Table 25 - Water quality problems in the study area

Parameter	Problem
Alkalinity	No problem, values at all nine sampling stations are greater than 20 mg/l.
Ammonia	Some violations. Average total ammonia is less than 2.0 mg/l for all stations. Ammonia values have exceeded 2.0 mg/l on the Goose River at Hillsboro and the Red River at the Grand Forks water intake and at Oslo. No data are available on un-ionized ammonia which is pH and temperature dependent. The rivers appear to be eutrophic and algal blooms can shift pH upwards and lead to ammonia toxicity to fish.
Arsenic	All values are less than 0.05 mg/l, the Federal Criteria and North Dakota Standards. The Minnesota Standard of 0.01 mg/l is equalled on an average at the Perley and Grand Forks water intake, and maximum values exceed this value at all sampling stations examined on the Red River of the North. Levels experienced may be background levels for these rivers.
Barium	No problem, all values less than 1.0 mg/l.
Beryllium	Limited data indicate no problem.
Boron	No problem in Red Lake or Red River of the North. Peak values at Hillsboro on the Goose River and average and peak values at Manvel on the Turtle River exceed the standard of 0.5 mg/l. Boron is a suspected carcinogen in aquatic organisms.
Cadmium	Peak values equal or exceed 0.01 mg/l at all examined Red River of the North sampling stations. Average and peak values exceed 0.01 mg/l at the East Grand Forks water intake station. Most values could be background, but levels over 0.03 mg/l experienced at East Grand Forks may be due to point sources.
Chloride	Average and peak values exceed 100 mg/l in the Turtle River at Manvel. Peak values have exceeded this North Dakota standard in the Goose River at Hillsboro and the Red River at the Grand Forks water intake. All Red Lake and Red River of the North sampling stations examined are within EPA criteria and Minnesota standards of 250 mg/l.

TABLE 25 (Continued)

Parameter	Problem
Chromium	Peak value at Oslo on the Red River of the North has exceeded 0.05 mg/l. The hexavalent form of chromium impairs reproduction at levels greater than 0.05 mg/l. Available information indicates this value is not exceeded.
Coliform (Total)	Values have exceeded 5,000/100 ml at all stations examined except the Turtle River at Manvel.
Coliform (Fecal)	Average and peak values exceed 200/100 ml at all stations examined except the Red River at Grand Forks water intake and the Turtle River at Manvel where average fecal coliform is less than 200/100 ml.
Color	Color has exceeded 75 units at most stations on the Red River and all on the Red Lake River. Average values are within the standards.
Copper	The Minnesota standard of 0.2 mg/l is met at all stations examined. The North Dakota standard of 0.05 mg/l has been exceeded in the Red River at Perley and at Oslo and the Red Lake River at East Grand Forks.
Cyanide	The North Dakota and Federal criteria of 0.005 mg/l for aquatic life has been exceeded at all stations examined on the Red Lake and Red River except the water intake at Grand Forks. Free cyanide is more lethal, but insufficient data on free cyanide are available.
Iron	Average and peak values exceed 1.0 mg/l in the Red River at Perley, Grand Forks water intake, and Oslo and in the Red Lake River at East Grand Forks. Peak values exceed 1.0 mg/l in the Goose River at Hillsboro and in the Red Lake River at Crookston. Values are below standards in the Turtle River and the Red River at the Grand Forks gage.
Hardness	Average and peak values exceed 500 mg/l in the Goose River at Hillsboro and the Turtle River at Manvel.

TABLE 25 (Continued)

Parameter	Problem
Flouride	No problem, all values less than 1.5 mg/l.
Lead	Average and peak values exceed 0.05 mg/l in the Red River at Oslo. Peak values exceed 0.05 mg/l in the Red River at Perley, Grand Forks water intake, and the Red Lake River at East Grand Forks. Lead does not appear to be a problem at the Grand Forks gage on the Red River.
Manganese	Average and peak values exceed 0.05 mg/l at all stations examined.
Mercury	All values are within North Dakota and Minnesota standards of 0.002 mg/l, but all average values exceed the Federal criteria of 0.00005 mg/l for aquatic life. No adequate information is available on whether this is organic or inorganic mercury.
Nickel	All values are less than 0.1 mg/l, the early Federal criterion, but bioassay tests need to be made to see if nickel is a problem.
Nitrates	Nitrates have exceeded 10.0 mg/l in the Red River at Halstead and at Oslo and the Goose River at Hillsboro.
Oil and Grease	No problem, all values well within limits of 10.0 mg/l.
Phenol	Average and peak values exceed 0.001 mg/l at all monitored stations. Peak values exceed the North Dakota standard of 0.01 mg/l at all monitored stations examined.
pH	No problem, all values between 6.5 and 9.0.
Phosphates	All average and peak values exceed 0.1 mg/l.
Selenium	Average values are within 0.01 mg/l. Peak values on the Red River approach or exceed this value. The high value in association with high arsenic values would indicate a high background level due to natural causes.
Silver	No problem, all values less than 0.05 mg/l.

TABLE 25 (Continued)

Parameter	Problem
Sulphates	Sulphates exceed 250 mg/l in the Goose River at Hillsboro and the Turtle River at Manvel on both an average and peak basis.
Suspended Solids	Average and peak values would indicate poor fisheries in the Red River and moderate fisheries in the Red Lake River.
Total Dissolved Solids	Peak values exceed 500 mg/l at all stations examined. Average values exceed this number in the Goose River and Turtle River.
Turbidity	Turbidity exceeds standards except in the Goose and Turtle Rivers.
Zinc	A zinc value greater than 1.0 mg/l has been recorded in the Red Lake River at East Grand Forks.

in table 25 indicates that chemical constituents, high turbidity, and high coliform levels limit the development of fisheries, exceed standards of safety for water supply, and prohibit safe recreation in and on the waters. The extensive and widespread nature of violations would indicate that upstream natural or nonpoint sources contribute heavily to violations. The quality in the Goose and Turtle Rivers is so poor that they are fit for very few human water supply or commercial freshwater aquatic uses, but may have recreation uses.

Fortunately, many of the pollutants that exceed standards in the Red River and Red Lake River are removed in the water treatment processes used by Grand Forks and East Grand Forks, making the rivers suitable as water supply sources.

Dissolved oxygen is also a prime determinant of the suitability of water for aquatic life. Low levels have occurred at each of the sampling stations examined on the Goose, Red, and Red Lake Rivers. These low levels have been attributed to high organic loads in the river and limited reaeration in the winter due to ice cover. More recent data would indicate that dissolved oxygen criteria are now being met.

Selected water quality data at Oslo on the Red River of the North downstream of the study area are shown in table 26. Analysis of the data indicates river dissolved oxygen was at or near saturation on all sampling dates of water year 1976. This sampling station should reflect the total urban contribution of pollutants to the Red River of the North from the urban area. It should be noted that fecal coliform, turbidity, and solids appear to be independent of flow, and thus may be natural phenomena. Nitrogen and phosphorus may increase slightly as flow increases indicating contributions from rural nonpoint sources.

Low dissolved oxygen also occurred at the Oslo sampling station on the Red River of the North downstream of the study area in July 1975 apparently because of nonpoint and intermittent point source discharges. Potential nonpoint loads to the Red River of the North from North Dakota upstream of this area have been estimated as follows:

Table 26 - Water quality data, Red River of the North at Oslo, MN (Water Year 1976)

Sample Date	Flow (cfs)	Solids (mg/1) TSS	TDS	JTU	DO (mg/1)	T(°C)	Nutrients (mg/1) TN	TKN	TP	K	Biological (No./100 ml) F. Coli.	F. Strep.	Phytoplankton
Sept. 21	584	46	217	20	9.2	15.0	0.8	0.8	0.09	3.2	250	100	110
July 27	1,000	123	302	40	7.2	25.0	0.8	0.8	0.17	3.6	20	40	55
Aug. 17	1,070	157	229	40	8.0	24.0	0.9	0.9	0.16	3.0	360	100	130
Jan. 20	1,500	8	319	7	11.4	0	1.1	0.8	0.08	3.9	410	790	8
Apr. 25	1,500	---	433	30	10.0	12.5	1.0	1.0	0.18	5.5	13	36	---
Feb. 24	1,600	6	313	6	11.6	0	1.8	1.4	0.11	3.7	---	---	8
June 29	1,620	151	294	60	7.0	20.5	1.9	1.6	0.28	3.8	1,000	240	43
Mar. 23	1,700	7	407	5	10.6	0	2.8	2.2	0.18	5.6	360	400	5
Dec. 17	2,000	---	398	7	13.4	0	2.7	2.5	0.28	5.2	---	---	250
May 25	2,020	66	338	20	8.8	17.0	0.9	0.9	0.13	4.5	30	20	240
Oct. 30	3,000	42	275	20	12.4	5.0	2.2	2.2	0.12	3.8	200	230	970
Apr. 27	5,060	115	373	26	11.7	10.0	1.5	1.3	0.17	5.5	440	290	53

Note: Pesticides and heavy metals were well within water quality standards.

Source: USGS Data.

	Annual Loads (million pounds)		
	BOD_5	TN	TP
Livestock Runoff	198	75	17.6
Cropland Runoff	6.9	8.9	1.0
Point Sources	1.9	0.9	0.5

The actual fractions of the above loads reaching the stream were estimated at 14 percent for nitrogen and 9 percent for phosphorus.

Similarly, nonpoint influences on the Red River of the North from Minnesota have been evaluated. Results are shown below (10):

Source	Load Indicator	Potential for Pollution
Livestock Runoff	44 lb BOD_5/sq mi/yr	Low
Fertilizer Use	$961/sq mi/yr	Medium
Other Chemical Use	$190/sq mi/yr	Low
Proportion of Erodable Soil	--	Low
Proportion of Clay Soil	--	High
Sand and Gravel Mining	380 ton/sq mi/yr	Low
Construction	0.017 housing units/sq mi/yr	Low
Unsewered	7 people/sq mi	Low
Overall	—	Medium to Low

These studies indicate a low potential for pollution from nonpoint sources.

Water quality standards, set to protect aquatic life, may be too stringent to be met by the rivers in the study area because of natural background levels. The observed poor fisheries in the Red River of the North could be due to historic low dissolved oxygen or simply the lack of the ability of aquatic organisms to adapt to the physical and chemical quality of the water.

These physical and chemical water quality problems exist upstream and downstream of the study area. The study area does contribute organic

loads through combined sewer overflows, wastewater treatment plant discharges, and urban nonpoint runoff. Removing or reducing these organic loads would enhance dissolved oxygen levels in winter and could remove a prime constraint to the development of game fisheries in the Red River of the North in the study area. There appears to be little that could be done in the study to improve significantly the physical and chemical quality of the river.

Water quality violations could be largely a natural phenomenon in the study area as the nature of the stream beds is such as to cause high suspended solids and turbidity and the clay may be adsorbing and desorbing metallic ions.

GROUNDWATER QUALITY

Groundwater in much of the study area is high in hardness and slightly saline with high to extremely high dissolved solids. The groundwater does not appear to be high in pollutants such as heavy metals, nitrates, or organics that could be induced by man. Some groundwater quality is being affected by high concentrations of septic tanks and drain fields in soils that do not drain easily.

WASTEWATER TREATMENT

Information on existing wastewater treatment facilities was presented previously. The adequacy of existing facilities is determined by applying the State design criteria to the lagoons to determine what population or load level they can accommodate. The forecast flow and load for each facility are used to estimate at what point in time the facilities will no longer meet criteria.

Grand Forks

The 341-acre primary cells can accommodate 10,230 lbs/day of BOD_5 at a design criteria of 30 lbs BOD_5/acre/day. With pretreatment facilities removing 50 percent of raw waste organic load, a total of 20,460 lbs/day of BOD_5 is the present system capacity. The total lagoon area of 632 acres can provide 180-day storage volume for

an average flow of 3.43 MGD. The projected flow and load in table 12 indicate that existing flow exceeds the capacity of the existing lagoons. Present city proposals for lagoon expansion will provide 495 acres of primary cells which can accommodate 14,850 lbs/day of BOD_5 at a design criteria of 30 lbs BOD_5/acre/day. If pretreatment facilities are expanded to provide 50 percent removal, then the wastewater treatment system can handle 29,700 lbs/day BOD_5. The city proposal will provide 180-day storage for an average flow of 7.22 MGD. This information indicates that the current waste treatment expansion project will serve Grand Forks until about 1995. Available information indicates that even though the design criteria are not met, the existing lagoons do produce an effluent meeting discharge criteria.

Required surface areas of primary and secondary lagoons to meet criteria through 2030 are as follows:

	Year					
Surface Area (acres)	1980	1990	2000	2010	2020	2030
Primary	296	328	380	434	490	551
Secondary	463	513	617	718	828	953

Surface areas above are based on the following:

1. Flows and BOD_5 for Grand Forks as shown in table 12.
2. That pretreatment facilities at the lagoons will be expanded in future years to provide a detention of 5 days and that 50-percent BOD_5 reduction will be achieved in these units.
3. Surface area for primary lagoons is based on a loading of 30 lb BOD_5/acre/day.
4. Surface area of secondary lagoons is based on the required storage volume for 180-day detention time. The 180-day storage volume is based on the volume between the 2-foot and 5-foot depth levels in the primary and to the full 5-foot depth in the secondary.

East Grand Forks

The 240-acre primary lagoon and 95-acre secondary lagoon can accommodate 7,303 lbs/day BOD_5 at an organic loading rate of 21.8 lbs BOD_5/acre/day. The 335 acres can serve the wastewater flow needs of 33,500 people or 3.35 MGD. The organic load criterion governs in this case. Projections in table 12 indicate these lagoons could become organically overloaded in about 1995. The existing lagoons do not meet three cell series design criteria, but appear to meet effluent criteria. The existing lagoons have been judged adequate to meet 1983 effluent criteria by the Minnesota Pollution Control Agency.

Required surface areas of primary and secondary lagoons to meet needs through 2030 are as follows:

Surface Area (acres)	Year 1980	1990	2000	2010	2020	2030
Primary	187	220	254	290	327	367
Secondary	77	81	90	100	111	126

Surface areas are based on flows and loads in table 12 for East Grand Forks and the same design factors as for Grand Forks except that no pretreatment facilities are provided for East Grand Forks.

Grand Forks Air Force Base

The primary lagoon can accommodate 2,070 lbs BOD_5/day or the organic load induced by a wastewater flow of 1.24 MGD with a strength of 200 mg/l BOD_5. The total lagoon area can provide 180 days storage for an average flow of 1.08 MGD. The facilities are not expected to need expansion, but the above information would indicate that they are marginally hydraulically overloaded at present even though effluent criteria are met.

Thompson

The lagoons at Thompson can presently handle the organic load from a population of 452 and the hydraulic load from a population of 235. Present facilities do not satisfy present population levels. The 201 Facilities Plan has addressed this deficiency.

Manvel

The lagoons at Manvel can presently handle the organic load from a population of 697 people and the hydraulic load from a population of 329 people. The system does not meet three cell design criteria but appears to be adequate to meet future growth for this community.

Emerado

The lagoons at Emerado can presently handle the organic load from a population of 572 people and the hydraulic load from a population of 306 people. The present system appears to be overloaded.

American Crystal Sugar

The lagoons at the American Crystal Sugar Company in East Grand Forks are meeting NPDES criteria because no discharge occurs. The system consists of primary clarification. Overflow from the clarifiers is recycled, and underflow is discharged to holding ponds that have been nondischarging for the last 5 years.

Other

Clustered new subdivisions south and west of Grand Forks are served with water by rural water associations or private cisterns and provide their own septic tanks and tile drain fields for sewage disposal. Indications from city of Grand Forks personnel are that these developments are too compact to be adequately and safely served by these systems.

SUMMARY

Standards and criteria for surface water quality and for evaluating wastewater treatment facilities have been presented in previous sections of this report. Major surface water quality problems identified in this report include high turbidity, high fecal coliforms, and potentially low dissolved oxygen following rainfall-runoff events and in winter under ice cover. High metallic ion concentrations could be due to natural background levels. The major problem with existing wastewater treatment facilities is that they do not satisfy State design criteria. All existing treatment facilities in the study area have been meeting their National Pollutant Discharge Elimination System (NPDES) permits. Water quality investigations indicate that the level of treatment provided and discharge controls used will be adequate to meet 1983 dissolved oxygen goals for fishable and swimmable waters at low river flow. Many physical and chemical water standards cannot be met in the rivers as natural background levels exceed standards. At high river flow, surface water quality problems may be due to nonpoint sources. Infiltration and inflow problems exist, but defining the extent of this problem for the area is beyond the scope of this phase of the urban study.

WASTEWATER MANAGEMENT ALTERNATIVES DEVELOPMENT METHODOLOGY

GENERAL

Previous sections have described the existing situation including the water resource problems in the study area. This section presents the concepts and methods used to develop potential solutions to problems identified in the study area.

GENERAL METHODS OF ANALYSIS

Efforts in this phase of the urban study are focused on reducing the myriad alternatives that are available to a few alternatives that can be examined in more detail in subsequent phases of the urban study effort. Each alternative action program must be compared to a no-action alternative since any action involves some cost and some benefit. The initial screening in this study is focused on the impact of actions on water resources, the costs of actions, and the environmental consequences of contemplated actions. The methods used in this study are outlined below.

Impact on Water Resources

The impact of point source discharges on surface water quality is determined using the mass balance and dissolved oxygen equations and kinetic constants presented in the section "Point Sources of Water Pollution." Subsequent studies may consider the influence of benthic demands and photosynthesis. The impact of nonpoint source discharges will be determined by mass balance of constituents contained in urban runoff and typical river water quality. These methods were used in the section "Nonpoint and Intermittent Point Sources" to identify potential existing problems. Subsequent studies may involve more complex mathematical modeling of urban runoff flow and intensive water quality sampling to better identify problems and the effectiveness of solutions.

Cost Development

Construction, operation and maintenance, as well as annual costs, are calculated for each alternative. The costs are based on cost curves and cost information presented in attachment B and this section. Cost-effectivenesss guidelines of the U.S. Environmental Protection Agency (47) are used as follows:

1. The economic life of mechanical facilities is assumed to be 25 years. Lagoons, intermittent sand filters, aerated lagoons, and land application systems are assumed to have a 50-year economic life. Treatment facilities are expanded when their design capacity is exceeded.
2. When the 25-year flow is less than 2 MGD, facilities are designed to meet 25-year needs. When the 25-year flow is greater than 2 MGD, then design capacity is for 25 years if the ratio of future flow to present flow is less than 1.3, for 15 years if the ratio of the 15-year flow to present flow is less than 1.4, and for 10 years if the ratio of the 15-year flow to present flow is greater than 1.4.

Environmental Assessment

During initial alternative formulation, environmental impacts can be evaluated in only a broad or general sense because the number of alternatives is large. A more comprehensive environmental impact assessment must be conducted in later phases of the urban study for a limited number of alternatives where a more site-specific type of analysis is feasible. For this report, biological (aquatic/terrestrial) and socioeconomic (land use/aesthetics) are used as general impact categories for this phase of the study.

WASTEWATER TREATMENT ALTERNATIVES

Wastewater management alternatives consist of various types and locations of treatment facilities required to treat the wastewater

generated in the study area. Each alternative consists of a combination of facilities and wastewater transmission lines serving one or more service areas. The costs, resources, and environmental effects resulting from the construction and operation and maintenance of those facilities and transmission lines are evaluated. The construction pattern is based on expansion of wastewater treatment facilities at various times to meet increased wastewater flows or replacement of facilities which are at the end of their economic life. The alternatives may utilize mechanical treatment processes, land application, or joint municipal-industrial treatment.

Type of Treatment Facilities

One objective of this study is to develop wastewater management alternatives that are responsive to various levels or degrees of treatment. Four levels of treatment are analyzed.

Level I treatment criterion is to maintain the existing level of treatment at existing treatment facilities. Treatment facilities are increased in capacity only to meet increased wastewater flows with no change in effluent quality.

Level II treatment criterion is secondary treatment defined by both States as an effluent quality of 25 mg/l BOD_5 and 30 mg/l TSS. Disinfection may also be required for certain facilities depending on specific water quality standards and public health needs.

Level III treatment criterion is additional treatment beyond secondary treatment. Effluent criteria of 10 mg/l BOD_5 and 10 mg/l TSS are used for this level. If water quality investigations indicate dissolved oxygen problems, then nitrification is considered.

Level IV treatment criterion represents no discharge of critical pollutants. The effluent quality for this level of treatment has been developed by the Corps of Engineers (48). Effluent limitations include 8 mg/l BOD_5, 5 mg/l TSS, 8 mg/l total nitrogen, 0.5 mg/l ammonia

nitrogen, 4 mg/l total nitrite- and nitrate-nitrogen, 0.1 mg/l total phosphorus, and 5 mg/l dissolved oxygen. It should be noted that the effluent quality required at this treatment level is extremely high and is probably the upper limit of effluent quality that can be achieved by existing, practical wastewater treatment technology.

If secondary treatment does not satisfy water quality standards, level III or IV treatment, as required, is used in the analysis of a given facility.

Types of treatment facilities selected to meet each treatment level are described as follows:

Level I - Uses existing unit processes at a treatment site for expanding or replacing facilities.

Level II - Activated sludge process with primary clarification and biological sludge handling facilities or with stabilization ponds.

Level III - Criteria can be met with the addition of a filtration system to either the activated sludge process or the stabilization pond effluent. If nitrification is required, it is designed into the activated sludge process.

Level IV - Advanced mechanical treatment processes or with land application of the effluent from a stabilization pond.

The mechanical system would include the activated sludge process followed by lime clarification to meet the 0.1 mg/l phosphorus requirement, biological nitrification-denitrification or clinoptilolite ion exchange is required to meet the ammonia and total nitrogen levels. The effluent from these unit processes would be filtered to meet suspended solids and passed through granular activated carbon columns to meet the BOD_5 criteria. Post-aeration would be necessary to raise the effluent dissolved oxygen concentration to the desired level.

Land application considered for the area was limited to the slow rate or cropland irrigation system. The poor drainability of the soils in the study area precludes the use of the rapid infiltration system. The overland flow land treatment process requires impermeable soils and

finished slopes of between 2 to 8 percent. Overland flow has had very limited application and does not give as high a degree of pollutant removal as the slow rate system. The raw wastewater would be delivered to a level II treatment facility with storage lagoons with sufficient capacity to retain flows during the approximately seven months when land application is not practicable. The treated wastewater would be disinfected prior to distribution with spray irrigation equipment. An application rate of 30 inches per year has been selected for initial screening. A pilot or demonstration program is recommended to test the technical feasibility of this concept for the study area.

Sludge handling facilities would be required for certain mechanical plants. The chemical and biological sludge treatment process selected is a function of plant size as follows:

	Sludge Handling Facilities	
Flow Range	Biological Sludge	Lime Sludge
Flow $\leq$ 3 MGD	Flotation thickening, aerobic digestion, & drying beds.	Gravity thicken & drying beds.
3 MGD < Flow < 10 MGD	Flotation thickening, anaerobic digestion, & vacuum filter.	Gravity thicken & vacuum filter.
Flow $\geq$ 10 MGD	Flotation thickening, centrifugation, filter press, and incineration.	Flotation thickening, centrifugation, & recalcination.

Land application or landfill of sludge residues would be required.

The types of treatment facilities contemplated to meet the four levels of treatment are shown in the schematics of figure 12 and figure 13.

Location of Treatment Facilities

A full range of technically feasible alternative plans was used in the application of the following basic strategies:

1. Maximum use of existing wastewater treatment facilities.
2. Maximum regionalization of wastewater treatment facilities.
3. Combination of regional facilities and use of existing wastewater facilities.
4. Synergistic use of the wastewater.
5. Joint municipal-industrial treatment of wastewater.

Subarea alternatives involving regionalization require transmission of wastewater from one or more service areas to regional facility sites. The costs for construction, operation, and maintenance of these transmission systems are balanced against the economies of scale associated with construction, operation, and maintenance of a regional treatment facility. The cost of transmission lines and pumping stations is given in attachment B.

Waste Flow and Load Reduction

Reduction of flow and/or load received at existing wastewater treatment plans would allow those plants to operate for a longer period of time at or below design conditions. This eliminates or delays the need for present facility expansion. There is also the potential for a higher treatment efficiency if the plants are operated below design capacity. Lower flows and loads would also mean lower plant operation and maintenance costs. Increased treatment efficiency would result in improved stream water quality. Conversely, flow reduction might also lower base flows in receiving streams or cause sewer odor problems due to lower sewer flows.

It is difficult to significantly reduce the strength of household wastewater except by reduced use of garbage grinders or elimination of phosphate detergents (35 to 50 percent of domestic phosphorus load). The volume of wastewater may be decreased by a number of methods. Water use may be lessened by:

1. Water conservation practices in the home.
2. Plumbing code changes to require use of water-saving devices in new construction.

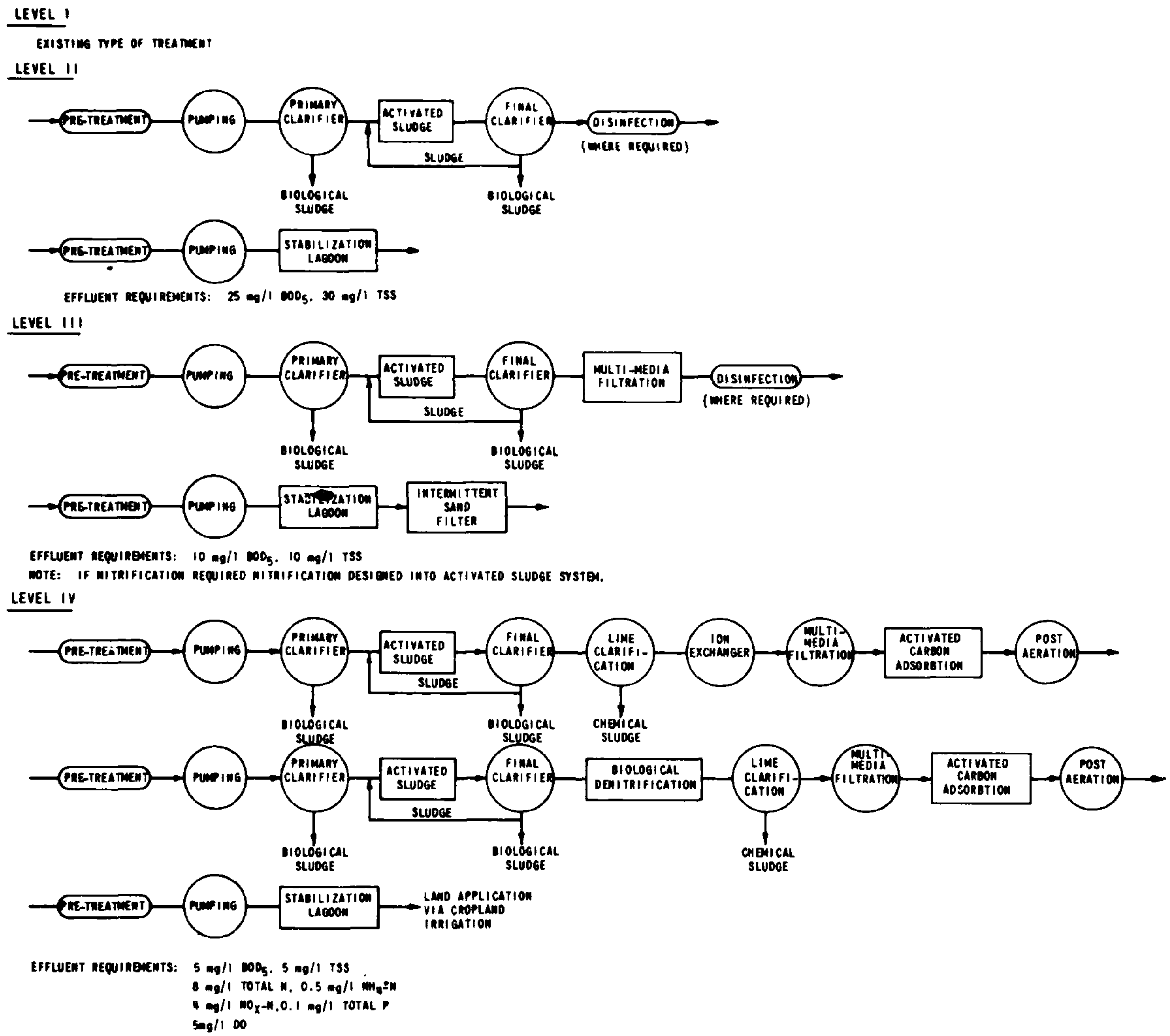


Figure 12 - Liquid Waste Treatment Schematics

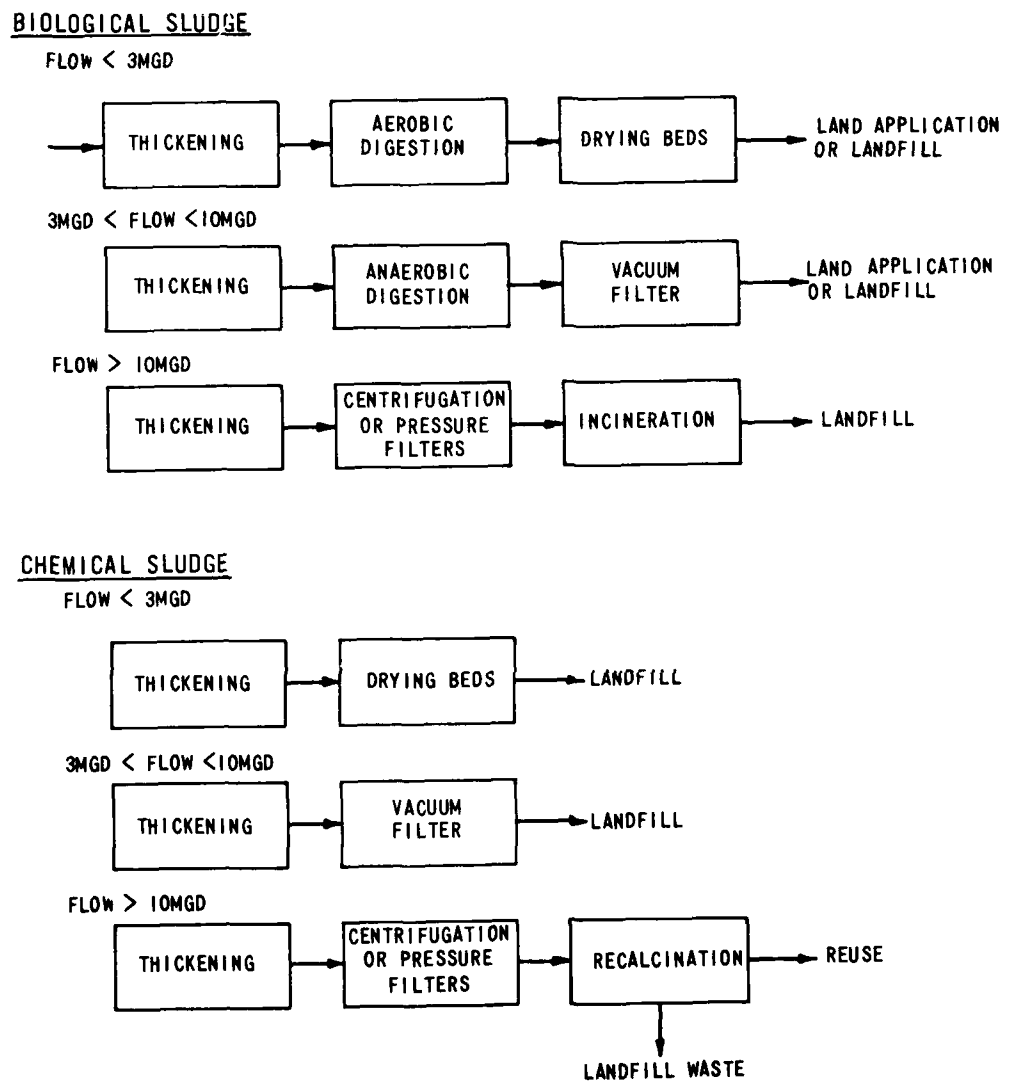


Figure 13 - Sludge Handling Schematics

3. Metering water and charging for actual use. This usually leads to less water use.
4. Use of water-saving devices ranging from simple faucet aerators to recycle toilets.
5. Reuse of wastewater within the home. This most often involves a cascade system where wastewater from laundry, lavatory, and/or tub or shower is used for toilet flushing.

The average toilet uses five to six gallons of water per flush. Virtually all manufacturers offer a 3.5 gallon per flush shallow-trap toilet. Dual flush toilets can reduce water use to 2.5 gallons per flush when solid matter is present or 1.25 gallons per flush when solid matter is absent by tripping the flush lever in the opposite direction. Using bricks or water-filled plastic bottles in the water closet is another inexpensive way to reduce water use in existing toilets. Flow reducing valves, water level controlled washing machines, and conservation practices can all reduce wastewater flow to the community's wastewater treatment system. An equally effective flow and load reduction option is to provide treatment at individual homes. The predominant form of on-site household wastewater treatment system is the septic tank followed by a soil absorption (leaching) field. Other systems include the use of an evapotranspiration bed sometimes referred to as the "mounds" system which uses sand placed on top of the existing soil to evaporate and treat the effluent from a septic tank in lieu of a leaching field. Aerobic treatment units are also used for individual on-site sewage treatment. These systems, basically aerated septic tanks, are followed by filters or leaching fields. In some areas, on-site treatment facilities are not acceptable and holding tanks are required. These are periodically pumped out and the contents discharged to a municipal system. Table 27 summarizes costs for on-site sewage treatment systems. On-site treatment systems are not recommended for the study area.

Table 27 - On-site sewage treatment systems - cost per home

System	Construction Cost ($)	O&M Cost ($/year)
Holding Tank Pumping and Transport	500	600-1,800
Septic Tank	500	20
With Soil Absorption Field	1,200-2,600	40
With Evapotranspiration Bed	2,400-4,500	40
With Intermittent Sand Filter	2,500	65
Plus Disinfection	3,500	105
Aerobic Treatment	1,000-2,000	80-135
With Soil Absorption Field	1,700-4,100	95-150
With Sand Filters	3,100-4,100	130-185
Plus Disinfection	4,100-5,100	170-225

NOTE: Costs adjusted to November 1977.

Source: Adapted from references (49,50,51)

In some instances small groups of residences or isolated businesses can be served by small package plants. Costs for these facilities are shown in table 28.

Table 28 - Costs for treatment options for small areas

	Installed Cost (thousands of dollars)[1]			
	Plant Size, (mgd)			
	0.01	0.05	0.10	0.50
Package Plants				
Extended Aeration[2]				
Range	29-79	61-92	90-162	140-405
Typical	45	80	120	260
Tertiary Filtration[3]				
Range	22-25	32-39	43-53	124-154
Typical	24	35	48	135

TABLE 28 (Continued)

	Installed Cost (thousands of dollars)[1]			
	Plant Size, (mgd)			
	0.01	0.05	0.10	0.50
Erected On-Site Plants				
Bio-discs[4]				
Range	52-75	140-200	216-308	584-835
Typical	64	171	263	711
Others	Use Cost Curves for Unit Processes in Appendix B			
Annual Operating Costs[5]				
Biological Package Plants				
Range	1-4	3-8	5-11	9-20
Typical	2.5	5.5	7.5	15
Tertiary Filter Package Plants				
Range	--	--	--	--
Typical	--	--	5	12

[1]Cost basis (November 1977).

[2]Includes cost of treatment plant, shipping, site preparation, erection and installation, and package lift station. Cost excludes sludge handling facilities, standby power, and lab or storage building. References (52, 53, 54, 55).

[3]Design flow of 1.0 gpm/ft^2, includes backwash storage and pumps, cleanwater storage, and air scour system. Reference (55).

[4]Complete plant installed. Reference (55).

[5]References (53, 55).

All of these devices can reduce domestic flow or load on a municipal system. Excessive infiltration/inflow in a municipal wastewater collection system can lead to hydraulic overloading of a wastewater treatment facility. The quantity of excessive infiltration/inflow is determined

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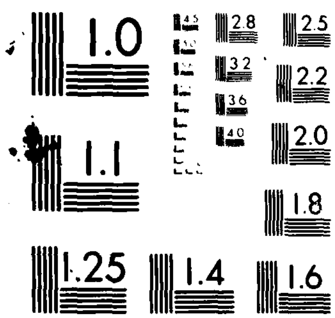

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in a cost-effective analysis comparing the cost of correcting the problem with the cost of providing additional treatment capacity to handle the increased flow. This cost-effective analysis is carried out as a part of Federal EPA 201 facility planning studies, and Federal regulations require that excessive infiltration/inflow be corrected before Federal grant monies can be made available to expand existing or construct new municipal wastewater treatment facilities.

Water reuse and recycle are common industrial practices. Municipal wastewater treatment plant effluent is often readily available and is usually of sufficient quality for many industrial cooling and process applications. Industries discharging to a municipal system are required to remove, by pretreatment, pollutants that the municipal facility is incapable of removing or which interfere with plant operation or efficiency. In the case of BOD_5, suspended solids, or fecal coliform, pretreatment may not be necessary unless industrial strength or volumes are excessive. Industries discharging wastes requiring pretreatment will choose the most advantageous of the following alternatives:

1. Build and operate facilities required to meet pretreatment standards.
2. Build and operate facilities for direct discharge to a receiving stream.
3. Eliminate the pollutant by process change, recycle, etc.

Nonstructural Controls

Primary nonstructural controls for wastewater treatment involve waste flow and/or load reduction measures presented previously. Certain areas in the study area are unsuitable for the use of on-site waste disposal systems, and problems of wastewater coming to the ground surface exist. Nonstructural controls to prevent this in the future would involve stringent city and county building codes and subdivision regulations.

Other practices used in the study area such as reduced service of water in restaurants are good examples of water conservation practices.

In alternative analysis, assumptions must be made on potential implementation of nonstructural control procedures which would alter the waste flow or load reaching treatment facilities. Types of assumptions involved may include:

1. The effectiveness of infiltration/inflow programs in reducing flows along with resultant changes in concentrations of wastewater constituents.
2. The degree of implementation of industrial waste pretreatment requirements and the effects this would have on load or compatibility of wastes to and from treatment facilities.
3. The extent to which recycle toilets, single home unit treatment, and similar self treatment processes would be used in the study area.
4. The extent to which policies encouraging use of septic systems, mound systems, and small group treatment to serve urban growth areas will be adopted.
5. The extent to which building code requirements for shallow water closets and flow limiting devices, etc., would be adopted.
6. The extent to which chemical bans (mercury use, phosphate detergent) will affect the degree or type of treatment needed.
7. The extent to which water reuse will be practiced. (Water reuse will probably be limited to irrigation, groundwater recharge, or industrial cooling water using effluent from treatment facilities.)
8. The extent to which river treatment (in-stream aeration, spoil and sludge bank removal) may obviate the need for a

high degree of treatment at a facility and the extent to which legal commitments to a high degree of treatment can be changed by the implementation of this practice.

Resource Use

Many other factors besides cost are involved in selection of wastewater treatment facilities as shown in table 29. Table 30 provides a guide for direct energy, chemical, and manpower requirements of selected processes that are useful in alternative analysis. Energy use is becoming an important consideration. Energy use of pumping is about 5 kWh/day/MGD/ft. of pumping head. The energy expended in construction of facilities can be approximated by the following (60):

$$\text{Energy for construction} = \frac{27{,}200\ \text{BTU}}{\text{dollar spent}} \times \frac{\text{ENRCCI}}{2{,}500} \times \text{Construction Cost}$$

ENRCCI = Engineering News Record Construction Cost Index = 2,500 in mid-1977

The indirect or off-site indirect energy use of various unit operations can be approximated using the data in table 31 applied to the chemical and energy use in table 30.

URBAN NONPOINT ALTERNATIVES

Considerably less experience is available with control methods for urban nonpoint alternative analysis. The remainder of this section presents information useful in the development and application of structural and nonstructural controls for urban intermittent and urban nonpoint pollution reduction.

Controls for Urban Intermittent Point Sources

Controls for urban intermittent point sources (storm sewers, combined sewer overflows) and urban runoff consist of both structural and nonstructural options.

Structural - Options used for structural control or urban intermittent point sources are shown on figure 14. Most installed systems are for control of combined sewer overflows. Cost and performance information useful in alternative analysis is presented in table 32.

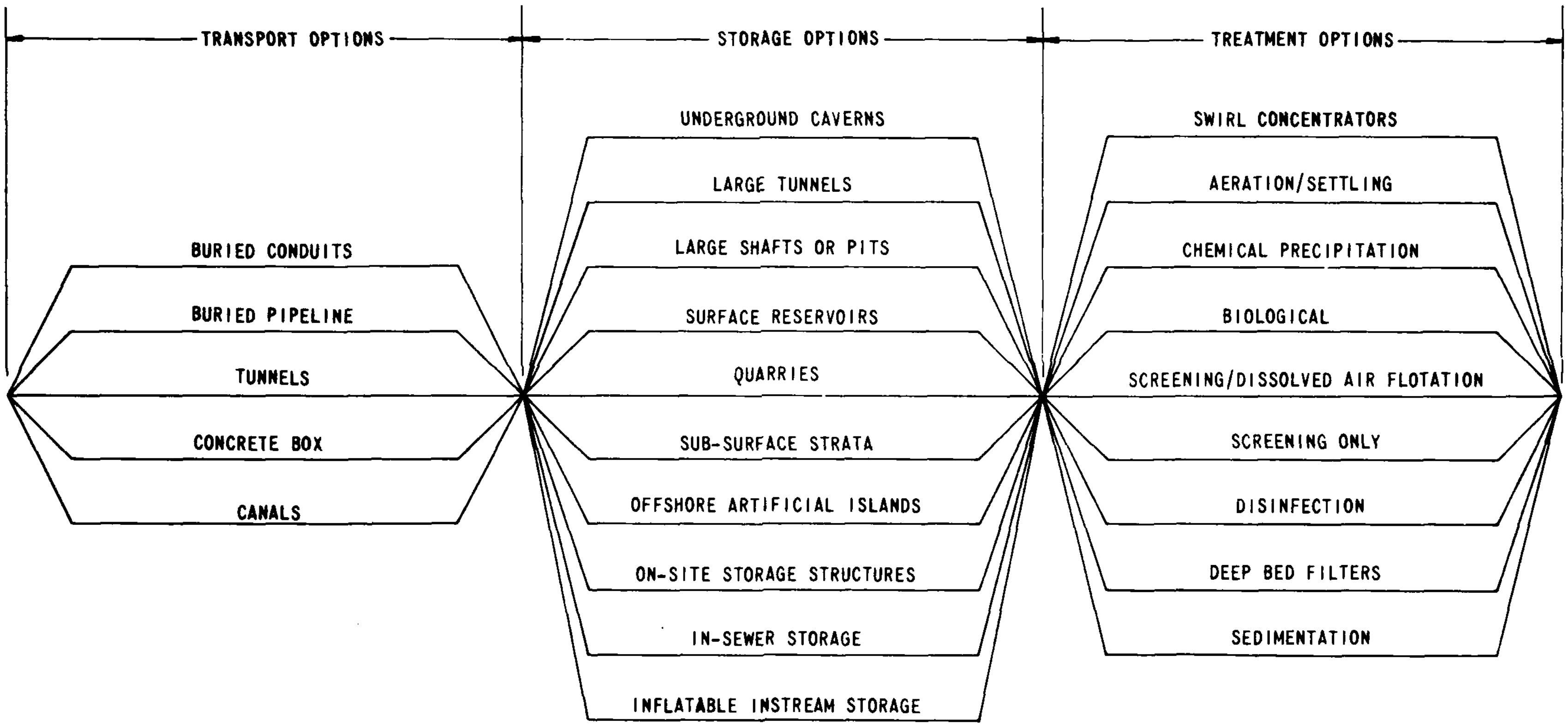


Figure 14 - Storage/Treatment Options

Table 29 - Factors other than costs normally considered in selection of wastewater treatment and sludge handling unit processes

	Land Requirements	Climatic Conditions	Ability to Handle Inlet Flow Variations	Ability to Handle Influent Quality Variations	Industrial Pollutants Affecting Process	Reliability of the Process	Ease of Operation & Maintenance	Occupational Hazards	Air Pollution	Waste Products
Preliminary Treatment	Min.	--	Good	Good	Min.	Very Good	Fair	Structures Mech.	Odors	Grit Screenings
Pumping	Min.	Freezing	Good	Good	Min.	Very Good	Fair	Structures Mech.	—	—
Primary Sedimentation:										
Conventional	Mod.	---	Fair	Good	Mod.	Good	Very Good	Structures	Odors	Sludges
With Chemicals	Min.	--	Good	Very Good	Max.	Very Good	Good	Chemicals	--	Sludges
Trickling Filters	Max.	Freezing	Good	Fair	Mod.	Very Good	Very Good	Structures	Odors	Sludges
Activated Sludge:										
Conventional	Mod.	—	Fair	Good	Mod.	Good	Fair	Structures	—	Sludges
With Chemicals	Min.	—	Good	Very Good	Max.	Good	Good	Chemicals	—	Sludges
Dual Media Filters	Mod.	—	Good	Good	Min.	Very Good	Good	Structures Mech.	—	Backwash Waste
Activated Carbon	Mod.	--	Good	Fair	Max.	Good	Good	Fires Explosion	Regenerant Gas	Spent Carbon
Two-Stage Lime Treatment	Max.	--	Good	Good	Min.	Very Good	Fair	Chemicals	—	Excess Sludg
Biological Nitrification	Max.	Cold	Fair	Fair	Mod.	Fair	Fair	Structures	--	Sludge
Biological Denitrification	Max.	Cold	Fair	Fair	Mod.	Fair	Fair	Chemical Explosions	—	Sludge
Ion Exchange	Min.	--	Fair	Good	Max.	Good	Good	Chemicals	Odor NH_3	Waste Regenerant
Lagoons	Max.	Freezing	Good	Good	Mod.	Fair	Very Good	—	Odor	None
Breakpoint Chlorination	Mod.	--	Good	Good	Max.	Very Good	Good	Chemicals	Chlorine Odor	*
Ammonia Stripping	Mod.	Cold	Fair	Fair	Min.	Good	Fair	Structures	Ammonia	Ammonia
Disinfection (Chlorine)	Min.	--	Good	Good	Max.	Very Good	Good	Chemicals	Chlorine Odor	*

*Increases effluent total dissolved solids.

Source: Based on Reference (56).

Table 30 - Estimated direct energy, chemical, and manpower use of selected processes

	Energy[7] (kWh/day)				Chemical (lb/day)				Chemical	Manpower[6] (man-yr/yr)			
Plant Size (mgd)	0.1	1	10	100	0.1	1	10	100	--	0.1	1	10	100
PROCESS													
Primary Clarifier[1]	110	250	1,270	4,000	--	--	--	--	--	0.82	2.6	5.5	28.0
Trickling Filter[2]	145	325	1,140	2,790	--	--	--	--	--	0.2	0.5	3.0	24.0
Activated Sludge[3]	165	800	3,100	9,900	--	--	--	--	--	0.5	1.0	7.9	40.0
Final Clarifier	55	125	635	2,000	--	--	--	--	--	0.41	1.3	2.7	14.0
Chlorination	1	8	60	500	8	80	800	8,000	Cl_2	0.1	0.5	1.0	2.0
Ozonation[9]	20	100	950	8,500	--	--	--	--	--	0.12	0.6	1.2	2.5
Alum Precipitation	5	40	350	3,000	126	1,260	12,600	126,000	Alum[8]	0.25	0.5	2.5	15.0
Lagoon	315	650	1,000	3,000	--	--	--	--	--	0.06	0.5	2.0	10.0
Land Disposal	120	800	4,600	18,800	--	--	--	--	--	0.1	1.0	10.0	55.0
Extended Aeration	306	960	--	--	--	--	--	--	--	0.66	2.6	--	--
Nitrification	150	700	2,800	9,000	--	--	--	--	--	0.5	1.5	3.5	8.9
Denitrification	3	10	100	1,000	42	420	4,200	42,000	Methanol	0.5	1.5	3.5	8.9
Lime Clarification	200	1,000	5,000	11,000	210	2,100	21,000	210,000	Lime	1.0	2.0	3.0	20.0
	--	--	--	--	260	2,600	26,500	265,000	CO_2	--	--	--	--
Lime Reclamation	500	4,000	18,000	80,000	--	--	--	--	--	0.5	1.0	1.5	8.0
Filtration	5	50	500	5,000	--	--	--	--	--	0.5	1.0	1.3	9.0
Carbon Treatment[4]	290	2,900	4,200	14,400	35	340	3,400	34,000	Carbon	1.5	3.0	4.5	29.0
Ion Exchange	120	1,200	12,000	45,000	10	90	900	9,000	Zeolite	0.2	0.5	1.2	2.0
	--	--	--	--	10	100	1,000	10,000	Salt	--	--	--	--
Rotating Biological Disks[5]	80	500	2,500	8,000	--	--	--	--	--	0.5	1.0	6.0	20.0
Ammonia Stripping	300	2,000	18,000	80,000	--	--	--	--	--	1.0	2.0	3.0	10.0
Reverse Osmosis	700	7,000	70,000	--	--	--	--	--	--	--	--	--	--
Microscreens	25	100	200	1,500	--	--	--	--	--	0.5	1.0	1.3	9.0

1 Includes sludge pumping.
2 Based on intermediate pumping.
3 Mechanical aerators.
4 About half for regeneration.
5 Designed for 90 percent removal, if 95 percent removal, design energy use is doubled.
6 The rapid increase of automation and instrumentation advances are expected to reduce manpower requirements for operations in the future.
7 Values in various references varied significantly for some unit operations.
8 Alum dosages variable, value given for 150 mg/l.
9 Ozone produced on site with dried air feed to ozonator.

Source: Based on References (56)(57)(58)(59)(60)(61)

Table 31 - Indirect energy use

Commodity	Energy Required for Production
Alum	2.5 million BTU/Ton
Polymer	2.0 million BTU/Ton
Chlorine	42.0 million BTU/Ton
Activated Carbon	102.0 million BTU/Ton
Lime	5.5 million BTU/Ton
Power	10,500 BTU/kwh

Source: Reference (62).

Past (63) and more recent (64,65,66) investigations all indicate that storage of stormwaters for subsequent release or further treatment is the most cost-effective structural treatment control option available. Storage facilities can be either large community systems with costs reflected in table 32 or smaller detention basins located strategically throughout a city. Cost and performance of smaller basins is provided in table 33. Sewer separation in combined sewer areas reduces the potential of intermittent point source discharges from this source. General costs for sewer separation are $10,000 per acre served for separation and $12,500 for total cost including plumbing changes (64).

Nonstructural - Nonstructural control methods to prevent surface water pollution from stormwater runoff in urban areas can be grouped into three major systems:

1. Methods to control the volume and rate of runoff.
2. Methods to control erosion and sediment delivery caused by runoff waters.
3. Methods to remove materials picked up or potentially picked up by runoff waters.

Table 32 - Summary of combined sewer overflow structural treatment options

Unit Processes[3]	Construction Costs[1] ($/mgd)			Operation Costs[1] ($/Year)			Approximate Average Removals[2]				
	5 mgd	50 mgd	500 mgd	5 mgd	50 mgd	500 mgd	BOD_5	TSS	P	TN	Fecal Coliform
Pretreatment	37,000	27,000	25,000	4,000	25,000	140,000	15%	15%	0	0	Low
Storage (cost per MG)	24,000	20,000	17,600	3,900	10,000	39,000	Depends on discharge point[4].				Moderate
Aerated Storage (cost per MG)	26,400	22,000	19,300	8,900	38,000	285,000	Depends on discharge point[4].				Moderate
Microstrainer	22,000	16,400	16,400	3,800	19,000	72,000	50%	70%	15%	10%	High
Dissolved Air Flotation	52,000	50,000	50,000	5,000	50,000	500,000	40%	60%	15%	10%	High
Dissolved Air Flotation with Chemicals	52,000	50,000	50,000	8,300	82,500	825,000	60%	80%	70%	20%	Moderate
Sedimentation Tanks	100,000	90,000	84,000	3,000	25,000	220,000	30%	50%	10%	2%	High
Disinfection	68,000	56,000	--	500	4,000	--	0	0	0	5%	Low
High-Rate Disinfection	3,500	3,300	--	800	6,000	--	0	0	0	5%	Low
Fine Screens	20,000	20,000	20,000	4,000	25,000	140,000	15%	15%	0	0	High
Swirl Concentrator	10,000	2,000	500	1,600	5,000	30,000	5%	20%	0	0	Low
High-Rate Filtration	94,000	38,000	30,000	25,000	68,000	290,000	55%	75%	30%	2%	Moderate
Pumping	48,000	17,600	14,400	600	2,500	21,000	--	--	--	--	--

[1] Capital and operating and maintenance cost curves from Reference (32) ENRCCI = 2,500.

[2] Effluent values will typically be higher during the first period of overflow and decrease as overflow continues.

[3] Details can be found in Reference (32).

[4] Storage alone estimated to remove 30 percent BOD_5, 60 percent TSS, 5 percent P, and 5 percent TN.

Source: Stanley Consultants

Table 33 - Cost and performance of detention basins

Runoff Storage	Size	Mass Removals (Percent) TSS	BOD$_5$	Cost Capital[1] ($/acre)	Annual O&M ($/acre)
0.1 in/acre	2,700 gal/acre	20	10	180	35
0.5 in/acre	13,600 gal/acre	40	25	600	30
1.0 in/acre	27,200 gal/acre	60	30	850	30
1.5 in/acre	40,700 gal/acre	70	35	1,200	30
5.0 in/acre	136,000 gal/acre	75	40	3,600	25

[1]Based on earthen structure with pipe outlet.
Concrete basins or tanks will cost about four times this amount.
Valid for basins serving 50 acres or less. ENRCCI = 2,500.

Source: Based on References (67,68,69).

Methods that have been reported in the literature for these basic systems are grouped in table 34.

Methods to control erosion and sediment delivery in urban construction are described in table 35.

Controls for Urban Nonpoint Sources

Many of the methods presented previously will control discharge of pollutants from overland flow urban runoff. A significant source of urban pollutants is the material deposited on urban street surfaces. Street cleaning, generally done for aesthetic purposes, assists in the removal of this potential load. Descriptions, removal characteristics, and costs for three types of street sweepers are presented in table 36.

Table 34 - Nonstructural control methods for urban areas

A. Methods to control the volume and rate of runoff.

- Rooftop storage or runoff controllers.
- Removal of illegal drain connections.
- On-site detention tanks, basins, and ponds.
- On-site seepage beds, pits, basins, and areas.
- Porous pavement and porous surfaces.
- Lawn aeration.
- Parking lot and plaza area storage.
- Diversion berms and channels.
- In-sewer storage.

B. Methods to control erosion and sediment delivery.

- Vegetative cover.
- Mulching and seeding.
- Surface stabilization.
- Sodded ditches.
- Temporary check dams.
- Sediment basins.
- Dikes, levees, and floodwalls.

C. Methods to remove materials potentially picked up by runoff waters.

- Air pollution control.
- Solid waste control.
- Street sweeping.
- Catch basin cleaning.
- Sewer flushing.
- Deicing material control.
- Vegetative filter strips.
- Swale storage.
- Dikes.

NOTE: Storage basins, aerated lakelets, and any further treatment are considered to be structural controls involving collection and treatment of stormwaters from large areas prior to discharge.

Source: Stanley Consultants

Table 35 - Urban construction erosion and sediment reduction controls

Controls	Application	Unit Cost (ENRCCI = 2,500)	Effectiveness
Surface Stabilization Methods			
Scarification	Cross-slope roughening.	---	Reduces gullying on short slopes.
Top Soil Removal	Aids in revegetation, strip 9" and reapply.	$.60/sq yd	Long term.
Gravel	On roads (1 ton/yd^2), in swales (1 ton/yd^2) and temporary berms.	$4-6/cu yd	Coarse sediment trap.
Asphalt Binder	Emulsion (300-500 gal/acre) to stabilize mulch or surface from wind blowing.	$.20/sq yd	98 percent soil loss reduction.
Latex Emulsions	Emulsion to penetrate surface to bind soil.	$.30/sq yd	95 percent soil loss reduction.
Surface Covering Methods			
Hay or Straw Mulching	Spread at 120-150 bales/acre (20-30 tons/acre) and disc in on slopes >5 percent.	$1,500/acre	98 percent soil loss reduction.
Wood Chip Mulching	Apply 1-inch deep over surface (10-15 tons/acre). (May use wood chipper on removed vegetation.)	$3,800/acre	94 percent soil loss reduction.
Paper Netting	Applied over seeding on steep slopes (can be reused).	$8,500/acre	90 percent soil loss reduction.
Sodding	For permanent protection (usually 1 inch thick).	$18,000/acre	99 percent soil loss reduction.
Seeding	25-50 lbs seed/acre (on areas stripped of topsoil add 2,000 lbs lime, 800 lbs fertilizer per acre).	$250/acre ($600-$800/acre)	95 percent soil loss reduction.
Wood Cellulose Fiber	Hydromulch at 1-2 tons/acre (hydromulch cost $600-$800/acre)	$.30/sq yd for fiber	95 percent soil loss reduction.
Sediment Trapping Methods			
Straw Bale Barriers	Spaced at 100' centers on contour of denuded slopes.	$6/ft	Between 40 and 60 percent solids trapped.
Shallow Trenches	Around stockpiled top soil or mounded materials.	$5/100 ft	Between 70 and 90 percent solids trapped.
Sand Bag Check Dams	As check dam, gravel weirs used 4-6' up and down stream.	$3/ft/ft height	Between 50 and 60 percent solids trapped.
Straw Bale Check Dams	As check dam, gravel weirs used 4-6' up and down stream.	$2/ft/ft height	Between 40 and 60 percent solids trapped.
Concrete Check Dam	For permanent installation - with chute spillway ($7/$ft^2$).	$350/cu yd	Between 70 and 90 percent solids trapped.
Sediment Transport Reduction Methods			
Sediment Basins	Trap 0.5" to 1" of runoff from tributary area, cleaned when capacity is cut in half.	See Table 33.	See Table 33.
Filter Screens	Grass filter strips around inlets or between site and stream channel.	$.50/$ft^2$	Traps sediment after movement.
Diversion Berms	Forces lateral (cross-slope) direction to water flow (2' x 4').	$2.50/ft length/ft height	Reduces erosion.
Channel, Slope, and Bank Protection Measures			
Sodded Ditches	For velocities less than 8 feet per second in drainage channels.	$1-$4/yd^2	Traps sediment, reduces gullying.
Timber Frame	2" x 4" frames are constructed on steep slopes and sod is put in frames.	$24,000/acre	Prevents gullying.
Check Dams	Can be used in channels to reduce gully erosion.	See Above	Prevents gullying.
Riprap	Rock facing on stream and channel banks.	$.80-$1.50/yd^2/inch thickness	Reduces bank erosion.
Gabions	Rock filled wire mesh on steeper banks or areas where dumping difficult.	$1.20-$1.80/yd^2/inch thickness	Reduces bank erosion.

Source: References (70, 71, 72, 73, 74)

Table 36 - Street sweeping - cost and effectiveness

Sweeper Type	Removal Mechanism (75)	Operating Speed (75)	Costs (75)			Removals[1] (percent)					
			Typical Vehicle	\$/Curb Mile	\$/Hour	Solids	BOD_5	TKN	TP	Metals	Pesticides
Pickup Broom	Gutter broom moves material to main pickup broom which sweeps material to a storage hopper.	4-8 mph	\$25,000	2-8	15-25	55	43	44	22	50	45
Regenerative Air	Air is used to blast material from the streets into a storage hopper.	4-8 mph	\$33,000	2-14	20-30	60	60	50	30	60	50
Vacuum	Suction removes materials from streets. The material is wetted in the sweeper and deposited in a vacuum cleaner.	4-8 mph	\$38,000	3-10	20-25	70-80[2]	75	60	40	75	60

[1] Removals are for one pass; the same percentage removal of remaining materials on subsequent passes may be expected. Volume of material picked up ranges from 0.2 to 0.5 cubic yards per curb mile cleaned (76). Values are estimated from data in References (75) and (76).

[2] In Chicago studies (77), vacuum sweeping after mechanical sweeping removed 95 percent of dust and dirt.

WASTEWATER MANAGEMENT ALTERNATIVES

GENERAL

Previous sections have identified water resource problems and have presented information necessary to analyze potential alternative solutions to those problems. This section develops potential alternative solutions to the wastewater management problems.

WASTEWATER TREATMENT ALTERNATIVES

There are nine significant point sources of water pollution in the study area: American Crystal Sugar, East Grand Forks municipal and minor industrial, Grand Forks municipal and minor industrial, International Co-op, Pillsbury, Thompson, Manvel, Emerado, and the Grand Forks Air Force Base. Currently there are seven treatment facilities, all stabilization ponds, and two pretreatment facilities to treat this waste. Current plans are to expand the Grand Forks lagoons and increase pretreatment and reduce water use at International Co-op. With nine significant point sources there are a total of eighty-one location and combination options and, with four levels of treatment for each location, a total of about 1,300 point source wastewater management options for the study area. Additional options involve the type of treatment used for meeting each level of treatment and potential use of wastewater flow and/or load reduction measures. Obviously many of these options are impractical and efforts must be made to reduce the theoretical options to practical solutions for the study area.

The large number of potential alternatives requires that certain options be given only casual consideration as professional judgment and knowledge of the existing situation in the area can be used to discard several unworkable or impractical alternatives from further consideration.

It is assumed, for example, that joint municipal-industrial treatment in Grand Forks is a practice that is preferred by the entities in the study area. Obviously, policies could be adopted that would require International Co-op and Pillsbury, among others, to treat their own wastewaters. This would in effect let the current Grand Forks lagoons meet treatment needs for a number of years without modification.

The city of Grand Forks faces immediate needs for improving treatment facilities and as a result of its facility planning efforts has determined that pretreatment imporvements, lagoon expansion, and outfall modifications best meet these needs. East Grand Forks is not faced with the need for immediate expansion.

A number of practical alternatives have been developed to meet the needs of the study area through the year 2030, and their cost and selected impacts are described in this section.

Initial consideration is given to one treatment facility for the region. The regional plant would be located at Grand Forks and would handle metropolitan and outlying point sources. All costs are based on the procedures of the previous section and cost information in attachment B. Each waste source is discussed in the following paragraphs.

Thompson

Wastewater flow is expected to increase from 0.053 MGD at present to 0.237 MGD in 2030. Options available for Thompson are to treat its own waste or to enter into the assumed regional treatment system. A regional solution would remove a significant point source to the Goose River but would require the construction of an interceptor force main and pumping station. The force main length is estimated to be 12 miles with a size of 12 inches. The required pumping station would be 700 gdm at 150 feet head. Costs and facilities of each option are explored below.

Thompson Alternative A - Facilities and costs involved in self-treatment for levels II, III, and IV follow. Treatment schemes for each level are shown on figure 12. Level II treatment uses lagoons, level III uses lagoons and sand filters, and level IV uses lagoons and land application but not sand filters. Sand filters are added in 1983 and land application is added in 1985.

		Cost	Notes
1980	Capital Cost	622,000	Lagoon, pretreatment, pumping
1980	O&M Cost	25,200	Lagoon, pretreatment, pumping
1983	Capital Cost	152,400	Sand filters in year 2030
1983	O&M Cost	1,840	For filters, increases to 2030 value
1985	Capital Cost	1,016,000	For land application to year 2030
1985	O&M Cost	10,200	For land application, increases to 2030 value
2030	O&M Cost	76,900	Lagoon and land application
2030	O&M Cost	6,200	Sand filters
2030	Salvage	250,000	Land

The equivalent annual costs of this system are $77,000 for level II treatment, $88,000 for level III treatment, and $139,000 for level IV treatment.

Thompson Alternative B - Facilities involved in regional treatment are:

		Cost	Notes
1980	Capital Cost	2,079,000	Pipeline and pump station
1980	O&M Cost	1,400	Pump station O&M
2030	O&M Cost	3,000	Pump station O&M

The equivalent annual cost of these facilities only is $152,000, which is greater than level IV treatment for Thompson alone. To this must be added the cost of regional treatment. Clearly self-treatment is more economical, and current plans for new lagoons should proceed.

The cost of transmission to a regional treatment facility exceeds on-site treatment by either lagoons or land application. Therefore, regionalization does not appear cost-effective for Thompson. If a regional land treatment option is adopted for the Grand Forks-East Grand Forks area and it is located near Thompson, then it may become economically attractive for Thompson to join.

Manvel

The population and thus future wastewater flow at Manvel are anticipated to be stable at 262 people and an average flow of 0.026 MGD. To enter into a regional facility would require the construction of approximately 10 miles of 4-inch interceptor force main and a 150-gpm 300-foot head pump station. Two alternatives were examined.

Manvel Alternative A - Facilities and costs involved in the three levels of treatment include:

		Cost	Notes
1980	Capital Cost	160,000	Upgrade existing lagoons
1980	O&M Treatment	13,000	Lagoon
1983	Capital Cost	40,000	Sand filters
1983	O&M Cost	1,400	For filters
1985	Capital Cost	283,000	Land application
1985	O&M Cost	13,000	Land application
2030	O&M Treatment	26,000	Lagoon and land application
2030	O&M Cost	1,400	For filters
2030	Salvage	120,000	Land

The equivalent annual cost of these facilities is $25,000 for level II, $28,000 for level III, and $48,000 for level IV.

Manvel Alternative B - A regional system would involve the following facilities:

		Cost	Notes
1980	Capital Cost	1,065,000	Pipeline and pump station
1980	O&M Cost	2,500	For pumping
2030	O&M Cost	2,500	For pumping

The equivalent annual cost of this alternative is $80,000 plus the cost of regional treatment which is significantly greater than treatment to level IV.

Manvel, like Thompson, is simply too far from the urban center to be economically served by regional facilities.

Emerado-Air Force Base

Emerado and the Air Force Base are considered jointly because of their proximity. Flow at Emerado is expected to increase from 0.09 MGD now to 0.20 MGD in 2030, while flow at the Air Force Base is expected to remain relatively constant at 1.13 MGD throughout the planning period.

Joint treatment using the Air Force lagoons would require the construction of approximately 10,500 feet of 12-inch interceptor force main and a 700 gpm-50 foot total dynamic head (TDH) pumping station and lagoon expansion to meet North Dakota design criteria.

Either joint or separate treatment would involve lagoon expansion to meet level I and level II criteria, the addition of sand filters to meet level III criteria, and land application (without sand filters) to meet level IV criteria.

Three alternatives are explored for these facilities.

Emerado-Air Force Base Alternative A - This alternative looks at facilities needed to meet level I, II, III, and IV criteria by separate expansion of existing facilities. Facilities involved for the Air Force Base are:

		Cost	Notes
1980	Capital Costs	381,000	Expand lagoons to 208 acres
1980	O&M Treatment	92,000	For lagoons to 2030
1983	Capital Costs	343,000	Sand filters for level III
1983	O&M Treatment	19,000	For filters to 2030
1985	Capital Costs	2,860,000	Land application for level IV
1985	O&M Treatment	69,000	For land application to 2030

The equivalent annual cost for level I and level II treatment is $120,000; for level III treatment is $156,000; and for level IV treatment is $316,000.

Facilities involved for Emerado separately are:

		Cost	Notes
1980	Capital Costs	260,000	Expand lagoons to 22 acres
1980	O&M Treatment	29,600	For lagoons increase to 2030 value
1983	Capital Costs	140,000	Sand filters for level III
1983	O&M Treatment	3,600	For filters increase to 2030 value
1985	Capital Costs	762,000	Land application for level IV
1985	O&M Treatment	12,000	For land application increase to 2030 value
2005	Capital Cost	260,000	Lagoon expansion
2005	Capital Cost	356,000	Land application expansion
2030	O&M Treatment	40,000	For lagoons
2030	O&M Treatment	6,000	For sand filters
2030	O&M Treatment	19,000	For land application

The equivalent annual cost for Emerado for level I and level II treatment is $51,000; for level III treatment is $62,000; and for level IV treatment is $119,000. The combined costs of separate treatment of the Air Force Base and Emerado are $171,000 for level I and II, $218,000 for level III, and $424,000 for level IV.

Emerado-Air Force Base Alternative B - This alternative provides joint treatment for Emerado and the Air Force Base. The interconnecting line and pump station would have a construction cost of $711,000 with operating costs of $2,000/year in 1980 increasing to $4,000/year in 2030. Other facilities involved are:

Table 37 - Emerado-Air Force Base alternative C costs

	Capital Costs				O&M Costs		
	Lagoons	Sand Filters	Land App.	Pipeline	Lagoons	Sand Filters	Land App.
1. Air Force Base Separate	$27,600	$20,300	$147,700	$ --	$ 92,000	$15,700	$48,400
2. Emerado Separate	18,800	8,300	47,200	--	32,300	3,400	9,800
3. Joint Facilities	30,800	23,300	167,400	54,900	89,300	18,000	56,100
4. Line 3 - (Line 1 + Line 2)	15,600	5,300	27,500	-54,900	33,000	1,100	2,100
5. 50% of O&M Savings	--	--	--	--	16,500	550	1,050
6. Joint Management Costs (Line 1 + Line 2 - Line 5)	46,400	28,600	194,900	--	107,800	18,550	57,150

		Cost	Notes
1980	Capital Cost	425,000	Increase lagoons to 225 acres
1980	O&M Treatment	85,000	Increase to 2030 value
1983	Capital Cost	394,000	Sand filters for level III
1983	O&M Cost	22,000	For sand filters
1985	Capital Cost	3,240,000	Land application for level IV
1985	O&M Cost	79,000	For land application
2005	Capital Cost	425,000	Lagoon expansion
2030	O&M Cost	102,000	For lagoons
2030	O&M Cost	23,000	For sand filters
2030	O&M Cost	82,000	For land application

The equivalent annual cost for treatment is $120,000 for level I and level II; $161,000 for level III; and $344,000 for level IV. The interconnect has an equivalent annual cost of $54,000 and when added to the treatment costs yields an equivalent annual cost of $174,000 for level I and level II, $215,000 for level III, and $398,000 for level IV for this alternative.

Emerado-Air Force Base Alternative C - The total costs of alternative A and B are nearly identical for levels II and III, with joint treatment appearing more cost effective for level IV treatment. The costs are based on separate management of facilities. Cost savings may also accrue in joint management of separate facilities. For this alternative it was assumed that joint management would result in 50 percent of the cost savings indicated for having only one facility to operate. The derivation of costs is summarized in table 37.

Summary - The preceding alternatives are summarized in table 38. Costs are allocated to each entity for each alternative. The results indicate cost savings are possible by joint management. Joint facilities are economically unattractive to Emerado.

Emerado and the Air Force Base could become part of a regional treatment system with Grand Forks-East Grand Forks. The annual cost of the force main interceptor (12 miles of 20-inch) and pumping station plus transfers from Emerado is estimated to be $378,000. This cost is almost equal to the cost of self-treatment and joint treatment and does not include treatment costs at Grand Forks. Depending on the feasibility and location of potential land treatment for the

Table 38 - Emerado-Air Force Base alternatives - cost summary

	Equivalent Annual Costs		
	Air Force Base	Emerado	Total
Joint Management (Alternative C)			
Level I	$107,000	$ 47,200	$154,200
Level II	107,000	47,200	154,200
Level III	143,100	58,200	201,300
Level IV	302,300	104,000	406,300
Separate Facilities (Alternative A)			
Level I	120,000	51,000	171,000
Level II	120,000	51,000	171,000
Level III	156,000	62,000	218,000
Level IV	316,000	108,000	424,000
Joint Facilities (Alternative B)			
Level I	102,000	72,000	174,000
Level II	102,000	72,000	174,000
Level III	137,000	78,000	215,000
Level IV	292,000	108,000	398,000

Grand Forks-East Grand Forks area, it may be feasible to have regional land application if level IV criteria are required. Removal of discharge to the Turtle River would reduce flow into the Kelly Slough National Wildlife Refuge which may be a constraint to this alternative.

Joint arrangements between Emerado and the Air Force Base may involve institutional problems on funding and management.

Grand Forks-East Grand Forks

The preceding alternatives indicate that it is not cost effective to regionalize outlying areas with the urban center. There are three significant treatment facilities in the urban area - Grand Forks lagoons, East Grand Forks lagoons, and American Crystal Sugar recycle lagoons. Future flow and load estimates for Grand Forks and East Grand Forks were presented in table 12. For purposes of wastewater planning, American Crystal Sugar options are:

1. Enter into a regional system in which a blowdown stream of 1.6 MGD with a BOD_5 of about 250 mg/l would be delivered

to a regional lagoon system. The tremendous flow variation would preclude economical mechanical plant design. In this alternative mechanical pretreatment could be used to lower BOD_5 sufficiently (less than 600 mg/l) to prevent odors in lagoons.

2. Adopt a land application system to handle the 1.6 MGD blowdown stream (or other self-treatment option).

Grand Forks and East Grand Forks have a number of alternatives that can be considered. Two basic strategies are explored:

1. Continued use of the lagoon method of treatment with additional facilities added to meet future flows.
2. Conversion of lagoon facilities to mechanical plants.

The second option would preclude total urban area regionalization.

Existing and projected flow and load for these three wastewater sources are summarized below:

	1980			2030		
	Flow (MGD)	BOD_5 (lb/day)	TSS (lb/day)	Flow (MGD)	BOD_5 (lb/day)	TSS (lb/day)
East Grand Forks	1.71	5,620	5,620	3.13	11,000	11,000
Grand Forks	5.80	17,770	19,280	11.62	33,030	30,230
American Crystal Sugar	1.60	3,340	3,340	1.60	3,340	3,340
TOTAL	9.11	26,730	28,240	16.35	47,370	44,570

MECHANICAL TREATMENT PLANT ALTERNATIVES

Mechanical treatment alternatives are based on an activated sludge process located along the Red River north of the urban area. The system would require about 5,000 feet of 36-inch force main with about 300 feet of river crossing. Flow from the master lift station in each city would be directed to this location. Six options were investigated to meet alternative effluent criteria. Those options and expected effluent quality are shown in table 39. Level II

Table 39 - Performance estimates - mechanical alternatives

		Final Effluent Concentrations (mg/l)					
Parameter	Raw Waste	Level II[1]	Level II A[2]	Level II B[3]	Level III A[4]	Level III B[5]	Level IV[6]
BOD_5	373	24	25	15	10	10	5
TSS	380	30	30	25	10	10	5
TN	45	32	10	20	25	10	8
NH_3-N	25	22	2.2	6	14.5	2.2	0.5
TP	12.9	10	8	7	6	6	0.1
D.O.	--	2.0	2.0	6.0	6.0	6.0	6.0

[1]Activated sludge only.

[2]Activated sludge designed for nitrification.

[3]Activated sludge followed by effluent polishing in lagoons.

[4]Activated sludge plus filtration.

[5]Activated sludge designed for nitrification plus filtration.

[6]Level III with lime clarification, ion exchange, activated carbon, and post aeration.

criteria used the activated sludge process only. A more reliable system to meet level II criteria involved using a new activated sludge facility with effluent passed through the East Grand Forks lagoons for final polishing. The activated sludge process designed for nitrification is also explored to meet level II criteria. Level III criteria are met by designing the activated sludge system with and without nitrification and adding effluent filtration. Level IV criteria are met by adding lime clarification with recalcination, ion exchange, activated carbon, and postaeration to the system. All alternatives include the sludge handling facilities described in the previous section. Costs are developed according to the criteria outlined in the section "Wastewater Management Alternatives Development Methodology" and cost information in Attachment B.

Certain assumptions were made to limit alternatives as follows:

1. Because of the seasonal water use of American Crystal Sugar, it would not be included in a mechanical plant.
2. Because Grand Forks is committed to lagoon expansion and has determined in facilities planning investigations that this is cost effective, the city would not enter a mechanical plant unless done jointly with East Grand Forks.

Mechanical Plant Alternative A

This alternative involves an activated sludge facility without nitrification. Costs and facilities involved are:

		Cost	Notes
1980	Capital Cost	9,130,000	For 9.1 MGD facility and piping
1980	O&M Cost	618,000	Increases linearly to 2030 value
1995	Capital Cost	4,660,000	Add 2.25 MGD (Total capacity = 11.35 MGD)
2005	Capital Cost	9,130,000	Replace 9.1 MGD facility
2010	Capital Cost	5,190,000	Add 3.4 MGD (Total capacity = 14.75 MGD)
2020	Capital Cost	4,660,000	Replace 2.25 MGD addition
2030	O&M Cost	1,031,000	For 14.75 MGD flow
2030	Salvage	3,834,000	For 2005, 2010, and 2020 additions and replacements

The equivalent annual cost of this alternative is shown in the following tabulation.

	Equivalent Annual Costs		
	Capital Cost	O&M Cost	Total
Grand Forks	$770,000	$566,000	$1,336,000
East Grand Forks	217,000	160,000	377,000
TOTAL	$987,000	$726,000	$1,713,000

Mechanical Plant Alternative B

In this alternative the effluent from the mechanical plant would be passed through the East Grand Forks lagoons. The effluent quality should be improved, and the use of the lagoons would allow regulation of system discharges to minimize the impact on water quality in the Red River of the North. Necessary interconnects and lagoon operation are estimated to have an equivalent annual cost of $52,000, with $11,000 allocated to East Grand Forks and $41,000 to Grand Forks.

Mechanical Plant Alternative C

A significant oxygen demand and potential toxicity to aquatic life can be induced by the ammonia in wastewater. This alternative adds nitrification to reduce effluent concentrations of ammonia. Costs and facilities involved in this alternative are:

		Cost	Notes
1980	Capital Cost	10,020,000	For 9.1 MGD facility and piping
1980	O&M Cost	656,000	Increases linearly to 2030 value
1995	Capital Cost	5,000,000	Add 2.25 MGD
2005	Capital Cost	10,020,000	Replace 9.1 MGD facility
2010	Capital Cost	5,575,000	Add 3.4 MGD
2020	Capital Cost	5,000,000	Replace 2.25 MGD addition
2030	O&M Cost	1,106,000	For 14.7 MGD flow
2030	Salvage	4,115,000	For 2005, 2010, and 2020 additions and replacements

The equivalent annual cost of this alternative is $1,847,000, consisting of $1,441,000 capital cost ($237,000-East Grand Forks, $841,000-Grand Forks) and $769,000 O&M cost ($169,000-East Grand Forks, $600,000-Grand Forks). Adding nitrification increases the equivalent annual cost by $134,000 over mechanical plant alternative A.

Mechanical Plant Alternative D

This alternative is the same as Alternative A except filtration is added in 1983 and incorporated in subsequent expansions and additions. The equivalent annual cost of the

addition is $319,000 ($193,000 capital, $126,000 O&M) resulting in a total alternative annual cost of $2,032,000.

Mechanical Plant Alternative E

This alternative is the same as Alternative C except filtration is added in 1983 and incorporated in subsequent expansions and additions, resulting in a total alternative annual cost of $2,166,000.

Mechanical Plant Alternative F

This alternative is the same as Alternative D except the unit processes of lime clarification, lime recalcination, ion exchange, activated carbon, and postaeration are added in 1985. Additional costs and facilities are:

		Costs	Notes
1985	Capital Cost	9,634,000	For 9.1 MGD advanced treatment processes
1985	O&M Cost	896,000	For advanced treatment
2000	Capital Cost	4,255,000	Add 2.25 MGD
2010	Capital Cost	9,634,000	Replace 9.1 MGD
2015	Capital Cost	4,660,000	Add 3.4 MGD
2025	Capital Cost	4,255,000	Replace 2.25 MGD
2030	O&M Cost	1,486,000	For 14.7 MGD advanced treatment
2030	Salvage	7,190,000	For 2010, 2015, and 2025 additions

The equivalent annual cost of these additions is $1,470,000 ($733,000 capital, $737,000 O&M costs) for a total alternative equivalent annual cost of $3,502,000.

Cost Summary

The equivalent annual costs of the preceding alternatives are summarized in table 40.

IMPACT OF MECHANICAL TREATMENT ALTERNATIVES

The impact of these discharges on water quality in the Red River is assessed by solving the dissolved oxygen sag equations for the 1990 and year 2030 discharge levels. Factors and assumptions used are:

7-day, 10-year low flow = 65 cfs
Initial River Dissolved Oxygen = 0.1
Background River Ammonia = 0.6 mg/l
Background River BOD_5 = 2.0 mg/l
K_1 = 0.35/day; K_N = 0.3/day; K_2 = 0.7/day

It is also assumed that there is no delay in nitrification in the river. This assumption along with assuming in-stream nitrification

Table 40 - Mechanical treatment plant alternatives cost summary

Alternative	Entity	Equivalent Annual Costs		
		Capital Costs	O&M Costs	Total
A (Level II)	Grand Forks	$ 770,000	$ 566,000	$1,336,000
	East Grand Forks	217,000	160,000	377,000
	Total	$ 987,000	$ 726,000	$1,713,000
B (Level IIB)	Grand Forks	$ 775,000	$ 602,000	$1,377,000
	East Grand Forks	218,000	170,000	388,000
	Total	$ 993,000	$ 772,000	$1,765,000
C (Level IIA)	Grand Forks	$ 841,000	$ 600,000	$1,441,000
	East Grand Forks	237,000	169,000	406,000
	Total	$1,078,000	$ 769,000	$1,847,000
D (Level IIIA)	Grand Forks	$ 920,000	$ 664,000	$1,584,000
	East Grand Forks	260,000	188,000	448,000
	Total	$1,180,000	$ 852,000	$2,032,000
E (Level IIIB)	Grand Forks	$ 991,000	$ 698,000	$1,689,000
	East Grand Forks	280,000	197,000	477,000
	Total	$1,271,000	$ 895,000	$2,166,000
F (Level IV)	Grand Forks	$1,492,000	$1,239,000	$2,731,000
	East Grand Forks	421,000	350,000	771,000
	Total	$1,913,000	$1,589,000	$3,502,000

occurs at a K_n = 0.3/day should make the resulting sag curves worst case type of events. The results of this analysis are shown on figure 15 and figure 16. These analyses indicate that only level III B and level IV will meet D.O. criteria of 5.0 mg/l for the assumed conditions in 2030. If $K_2 = 0$ in winter conditions, the minimum dissolved oxygen is about 4.9 mg/l with level IV and 2.9 mg/l with level III B for the 2030 flow condition. Only the most advanced treatment would resolve the problem of low river dissolved oxygen under winter ice cover at low flow under continuous discharge conditions. Using the existing East Grand Forks lagoon as a holding pond to control discharge may alleviate this difficulty.

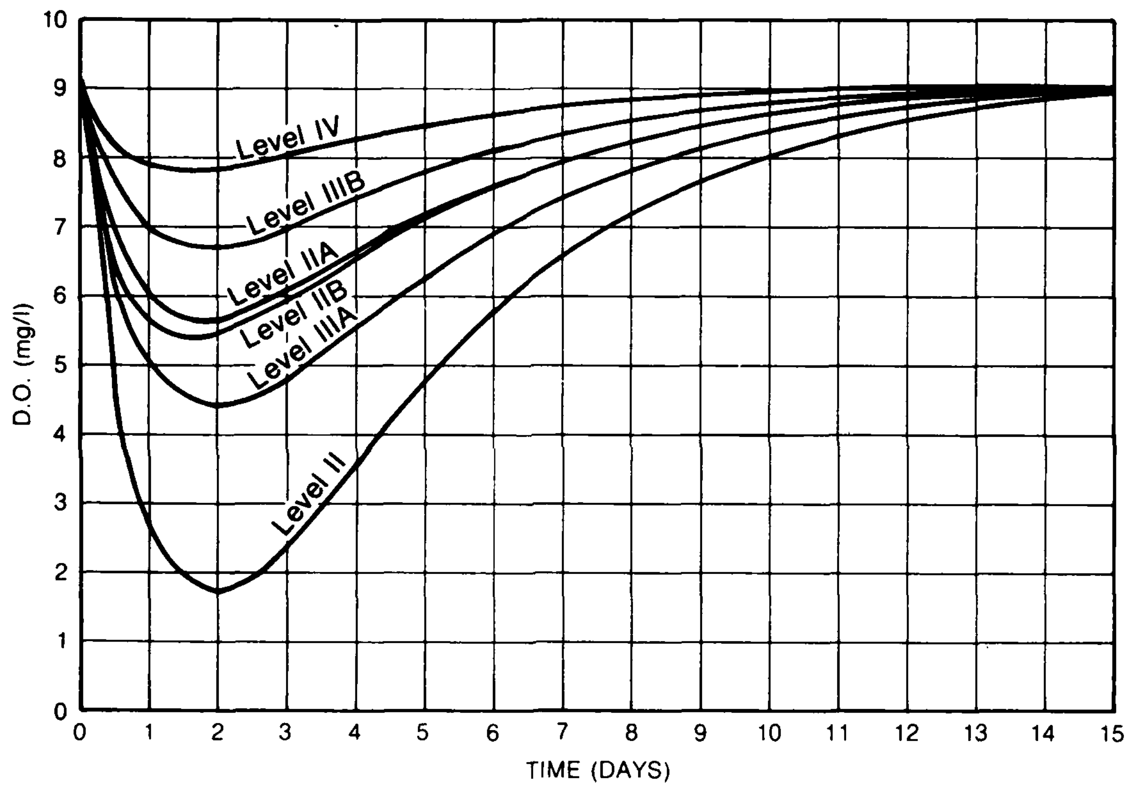


Figure 15 - Dissolved Oxygen (D.O.) Profiles
1990 Discharge Conditions

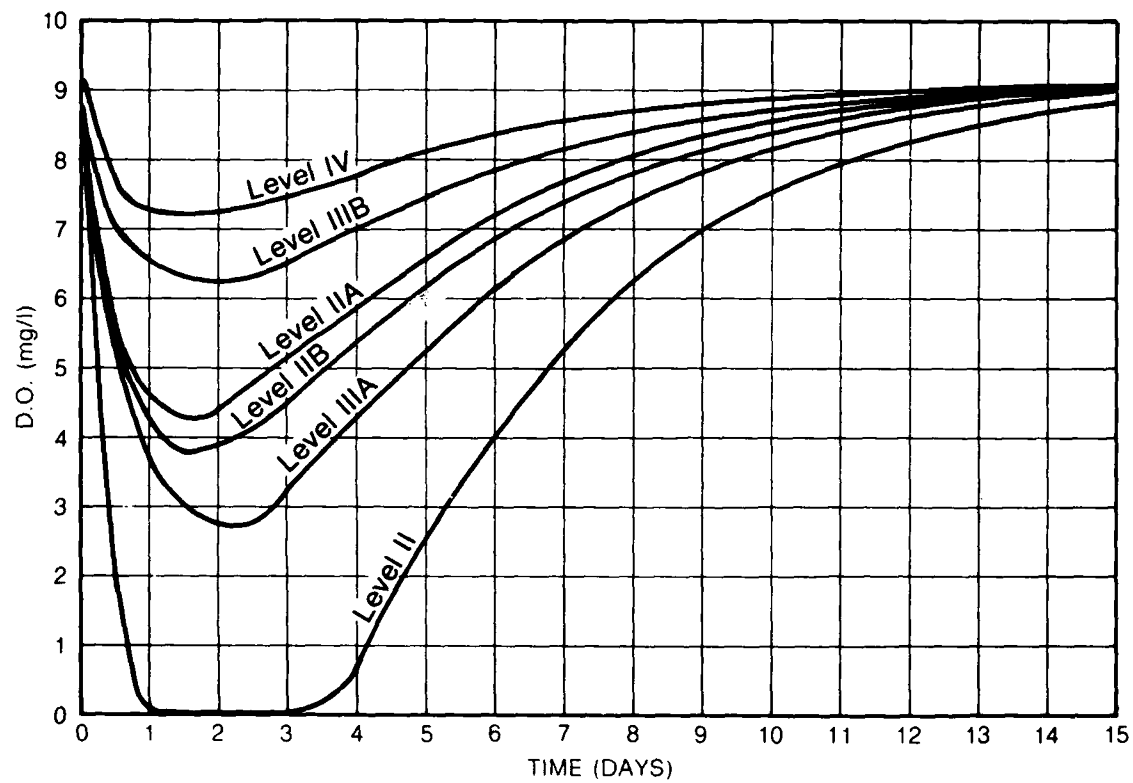


Figure 16 - Dissolved Oxygen (D.O.) Profiles
2030 Discharge Conditions

LAGOON TREATMENT ALTERNATIVES

The other series of alternatives uses the stabilization lagoon as a base. The current programs in the study area strongly favor the adoption of this alternative. The lagoon treatment method where wastewaters are stored during low flow periods affects water quality whether or not discharge occurs. At low river flows, water that is removed from the river is not directly returned, leading to lower flow and less assimilative capacity downstream of the study area. During discharge, the dissolved oxygen equations can be used to predict the impact of the discharge on this indicator. However, the discharge from these facilities can be controlled to allow river dissolved oxygen criteria to be met.

The major disadvantage of stabilization lagoons is the land area required. Presently there are about 970 acres of land used for treating wastewater from the Grand Forks-East Grand Forks urban area. To treat 2030 flows would involve use of over 2,000 acres for lagoons, and, if land treatment is added, about 6,500 acres would be required at the assumed application rate.

Alternatives for each major facility are explored separately, then various combinations of facilities are examined. All facility expansions are designed to meet State design criteria for level I and level II treatment. Sand filters are added in 1983 to meet level III criteria. If more advanced treatment is required, then land application of wastewaters from lagoons is added for level IV treatment. The various alternatives are discussed in the following pages.

Grand Forks

The city of Grand Forks is proceeding on implementation of their facilities planning effort. Proposed facilities and costs include:

	Cost
New lagoons	$5,594,000
New pretreatment	$1,045,000
New outfall	$2,485,000

Based on projected flows and loads in this report, additional facilities would be required in 1995 and 2010 to meet future needs.

Grand Forks Alternative A - Costs and facilities included in meeting level I and level II criteria are:

		Cost	Notes
1980	Capital Cost	9,246,000	Present proposal plus preliminary
1980	O&M Cost	283,000	Increases linearly to 2030 value
1995	Capital Cost	2,781,000	Lagoon and pretreatment expansion
2010	Capital Cost	3,440,000	Lagoon and pretreatment expansion
2030	O&M Cost	408,000	For 11.6 MGD flow
2030	Salvage	2,142,000	For land and lagoons

The equivalent annual cost of level I and level II treatment is $1,087,000 with $773,000 being capital cost and $314,000 being O&M cost.

Grand Forks Alternative B - Adding sand filters in 1983 and subsequent expansions would increase the equivalent annual cost to $1,308,000 with $916,000 for capital cost and $392,000 being O&M cost.

Grand Forks Alternative C - Adding land application in 1985 would increase the equivalent annual cost to $2,106,000 with $1,559,000 capital cost and $547,000 O&M cost.

Additional costs and facilities are:

		Cost	Notes
1985	Capital Cost	13,462,000	Land and irrigation
1985	O&M Cost	280,000	For 6.4 MGD flow
2000	Capital Cost	4,445,000	Land application expansion
2015	Capital Cost	4,445,000	Land application expansion
2030	O&M Cost	470,000	For 11.6 MGD system
2030	Salvage	9,410,000	Land and equipment

Grand Forks Alternative D - Present plans call for lagoon expansion, pretreatment expansion, and outfall modification. If land application is required as outlined in alternative C, then a degree of cost savings can be obtained by eliminating outfall modifications. Pretreatment and lagoon expansion would still be required to provide adequate treatment and storage prior to land application. The equivalent annual cost of the outfall modification is $180,000. The schedule of project implementation and funding factors reduce the feasibility of this approach.

East Grand Forks

The present lagoon facilities have adequate surface area and detention time to meet the needs of East Grand Forks until about 1990. The facilities do not meet three-cell design criteria of the State of Minnesota.

East Grand Forks Alternative A - Level I and level II involve lagoon expansion only. Costs and facilities included are:

		Cost	Notes
1980	O&M Cost	123,000	Increases linearly to 2030 value
1990	Capital Cost	1,600,000	Lagoon expansion
2010	Capital Cost	1,310,000	Lagoon expansion
2030	O&M Cost	173,000	For 3.1 MGD flow
2030	Salvage	872,000	Land and lagoons

The equivalent annual cost of this alternative is $205,000 with $70,000 being capital cost and $135,000 being operating and maintenance cost.

East Grand Forks Alternative B - Adding sand filters in 1983 and subsequent lagoon expansions would add $75,000 ($36,000 capital, $39,000 O&M) to the equivalent annual cost of alternative A.

East Grand Forks Alternative C - Adding land application in 1985 and subsequent lagoon expansions would add $390,000 ($306,000 capital, $84,000 O&M) to the equivalent annual cost of alternative A.

American Crystal Sugar

Most wastewater discharges from American Crystal Sugar are produced from August to February and discharged, if effluent criteria are met, in April and May at high river flows. If criteria are not met, the contents of the lagoons must be held. Options available for the industry are continued self-treatment or realization with East Grand Forks or an urban area system. Regionalization would involve about 10,800 feet of 18-inch force main and a 3.0-MGD pumping station (50 foot TDH). Separate systems are discussed below.

American Crystal Sugar Alternative A - This system is based on using the existing transport pond as primary treatment and adding 80 acres of lagoons for storage and secondary treatment. A 1.0-MGD land application system is also included. The capital cost of the system is estimated at $2,790,000, with annual operating cost of $126,000. The equivalent annual cost is $326,000. This system is used for level III and level IV treatment. The equivalent annual cost of lagoons only is $115,000 ($53,000 capital cost and $62,000 O&M cost).

American Crystal Sugar Alternative B - This system is based on using a pretreatment system similar to the one being installed at

Moorhead. This system consists of fine screening, primary clarification and secondary treatment consisting of first anaerobic digestion of the liquid stream followed by the activated sludge process. The system is designed for an overall BOD_5 removal of 95 percent. The present lagoons would receive the effluent and discharge it when effluent criteria are met. The capital cost of the system is estimated at $2,000,000 with annual operating cost of $176,000. The equivalent annual cost is $321,000.

Joint Treatment Alternatives

Several possible combinations of treatment facilities are possible for the major wastewater producers in the urban area. Three overall options are explored as follows:

Joint Option A - This option explores a single treatment facility for the urban area. Transmission systems consist of 10,800 feet of 18-inch force main from American Crystal Sugar to East Grand Forks master lift station. A pumping station with design flow of 3.0 MGD at TDH of 50 feet is used to transfer waste. East Grand Forks and American Crystal Sugar wastes are transmitted to the Grand Forks lagoons through four miles of 30-inch force main including 300 feet of river crossing. A 10.0 MGD at TDH of 50 feet pump station is used to transfer waste. Costs and facilities for level I treatment are:

		Cost	Notes
1980	Capital Cost	2,600,0C0	Transport to Grand Forks
1980	Capital Cost	814,000	Transport to East Grand Forks
1980	Capital Cost	13,358,000	Lagoon, pretreatment, outfall
1980	O&M Cost	363,000	Treatment increases to 2030 value
1995	Capital Cost	3,318,000	Lagoon and pretreatment expansion
2010	Capital Cost	4,020,000	Lagoon and pretreatment expansion
2030	O&M Cost	505,000	For 16.4 MGD flow
2030	Salvage	6,451,000	For land and reservoirs

The equivalent annual cost of this option is $1,784,000. Costs are allocated on the basis of average flow for the 50 years and facilities used (i.e., American Crystal pays for transfer pipe and pump as it is the only user). On this basis, costs can be allocated to $292,000 for American Crystal Sugar, $358,000 for East Grand Forks, and $1,134,000 for Grand Forks.

For level III, sand filters are added in 1983 and subsequent expansions. These additions would increase the equivalent annual cost to $2,182,000.

Adding land application in 1985 and subsequent expansions would increase the equivalent annual cost to $3,258,000.

Joint Option B - This alternative considers joint treatment for Grand Forks and East Grand Forks with separate treatment for American Crystal Sugar. The transmission line needed would be 4 miles of 24-inch with 300 feet of river crossing plus a 9 MGD pump station (TDH of 50 feet). Costs and facilities for level I treatment are:

		Cost	Notes
1980	Capital Cost	2,074,000	Transport to Grand Forks
1980	Capital Cost	11,500,000	Lagoon, pretreatment, outfall
1980	O&M Cost	307,000	Increases linearly to 2030 value
1995	Capital Cost	3,660,000	Lagoon and pretreatment expansion
2010	Capital Cost	3,660,000	Lagoon and pretreatment expansion
2030	O&M Cost	473,000	For 14.75 MGD
2030	Salvage	5,990,000	For land and lagoons

The equivalent annual cost for Grand Forks and East Grand Forks is $1,616,000. The equivalent annual cost for level III is $1,904,000 and for level IV is $2,949,000. Costs for American Crystal are those from American Crystal Sugar Alternative A.

Joint Option C - This alternative examines joint treatment by East Grand Forks and American Crystal Sugar with separate treatment for Grand Forks. Costs and facilities involved for level I and II treatment are:

		Cost	Notes
1980	Capital Cost	3,216,000	For lagoon expansion and preliminary
1980	Capital Cost	1,034,000	For interconnect and pump station
1980	O&M Cost	131,000	Increases linearly to 2030 value
2005	Capital Cost	1,308,000	Lagoon expansion
2030	O&M Cost	205,000	For 4.7 MGD
2030	Salvage	470,000	Land and lagoons

The equivalent annual cost is $474,000. The equivalent annual cost for level III treatment is $664,000, and for level IV treatment is $1,234,000.

Summary and Conclusions

A variety of alternatives have been examined for the study area. Table 41 summarizes the costs of the five major sets of alternatives for the urban area. The costs presented for alternative 5, Joint Mechanical Treatment, are the least cost alternative to achieve the given level of treatment and are taken from Table 40. Alternative 1, with separate lagoon based systems for Grand Forks, East Grand Forks, and American Crystal Sugar, is the least cost alternative for each of the treatment levels. A joint mechanical treatment system is the most expensive system for all treatment levels.

In order to provide total study area wastewater management costs, the total annual costs for the rural alternatives (Thompson, Manvel, Emerado, and the Air Force Base) are shown and added to the total urban area costs to give total study area costs. Total rural area costs are the sum of separate wastewater treatment costs for each of the entities as regionalization was shown not to be cost effective.

Figures 17 through 21 show each of the five urban area alternatives. These figures are conceptual only. They indicate the relative location of treatment facilities and new wastewater transmission lines and the areas required for sewage lagoons and land application systems to meet the wastewater treatment needs of the urban area through the year 2030. Areas for land application are shown adjacent to existing treatment facilities. No site investigations were conducted in this study to show whether these areas contain soil types suitable for land application systems. For the lagoon based systems, lagoons are required for level II treatment, lagoons and sand filters for level III, and lagoons and land application for level IV treatment.

The ultimate degree of treatment required in future years is not known. If level IV treatment is required, the tremendous land area required for land application is a factor that must be considered in more detail. This study did not include any site specific analyses to determine the suitability of land treatment in the study area. If level IV treatment is required a more detailed analysis including some

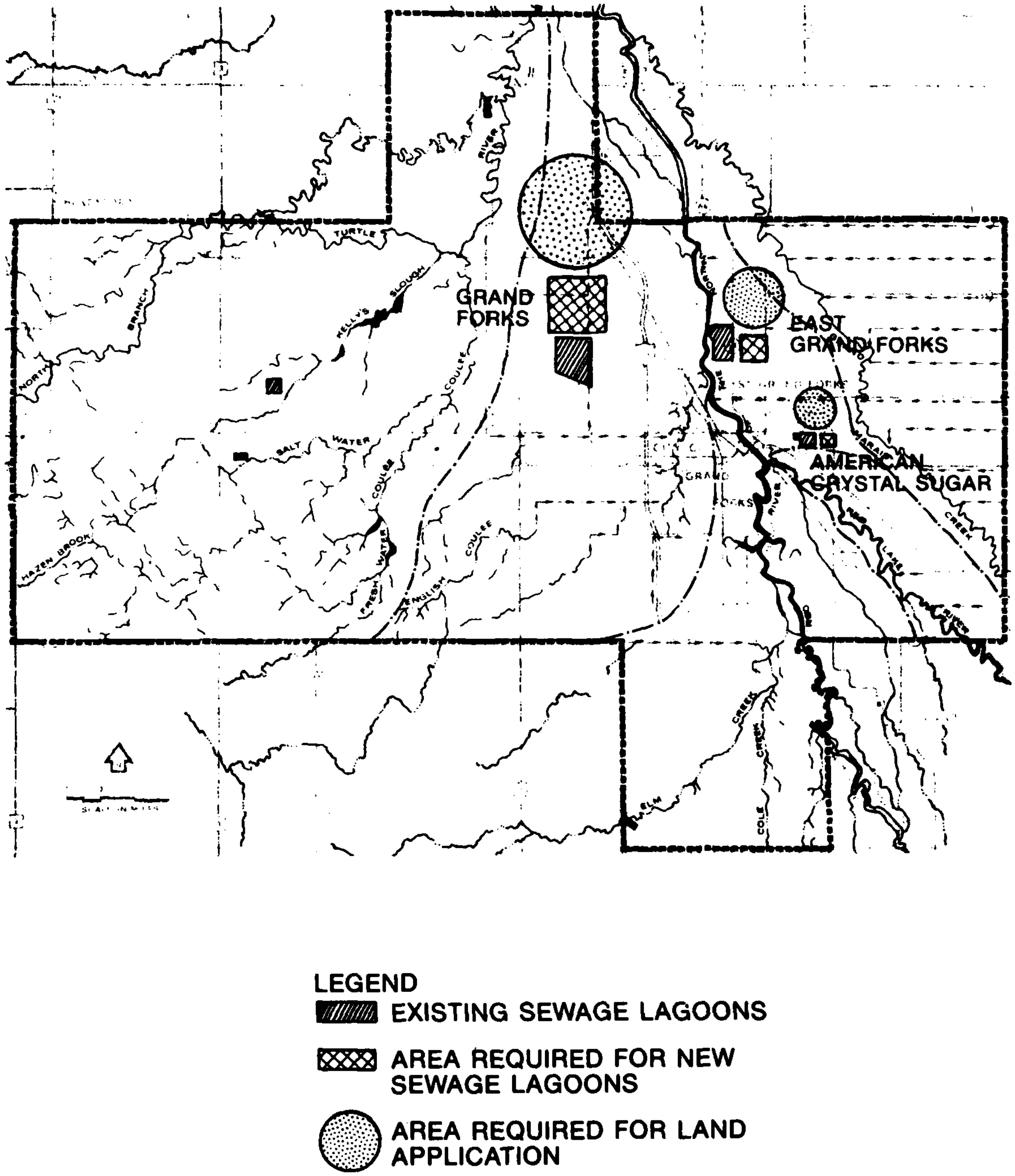
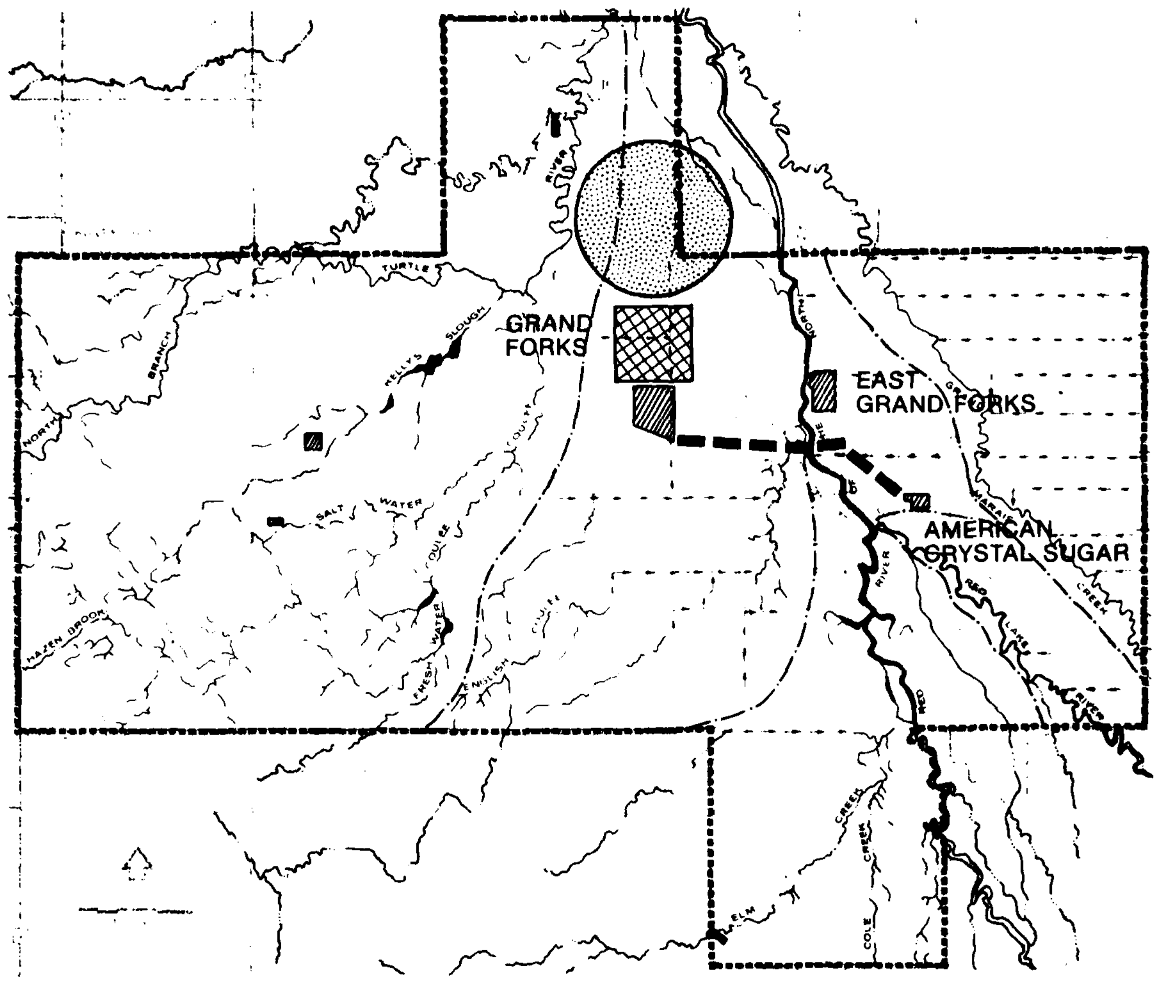


Figure 17 — Wastewater Management Alternative 1



LEGEND

EXISTING SEWAGE LAGOONS

AREA REQUIRED FOR NEW SEWAGE LAGOONS

AREA REQUIRED FOR LAND APPLICATION

NEW WASTEWATER TRANSMISSION LINE

Figure 18 — Wastewater Management Alternative 2

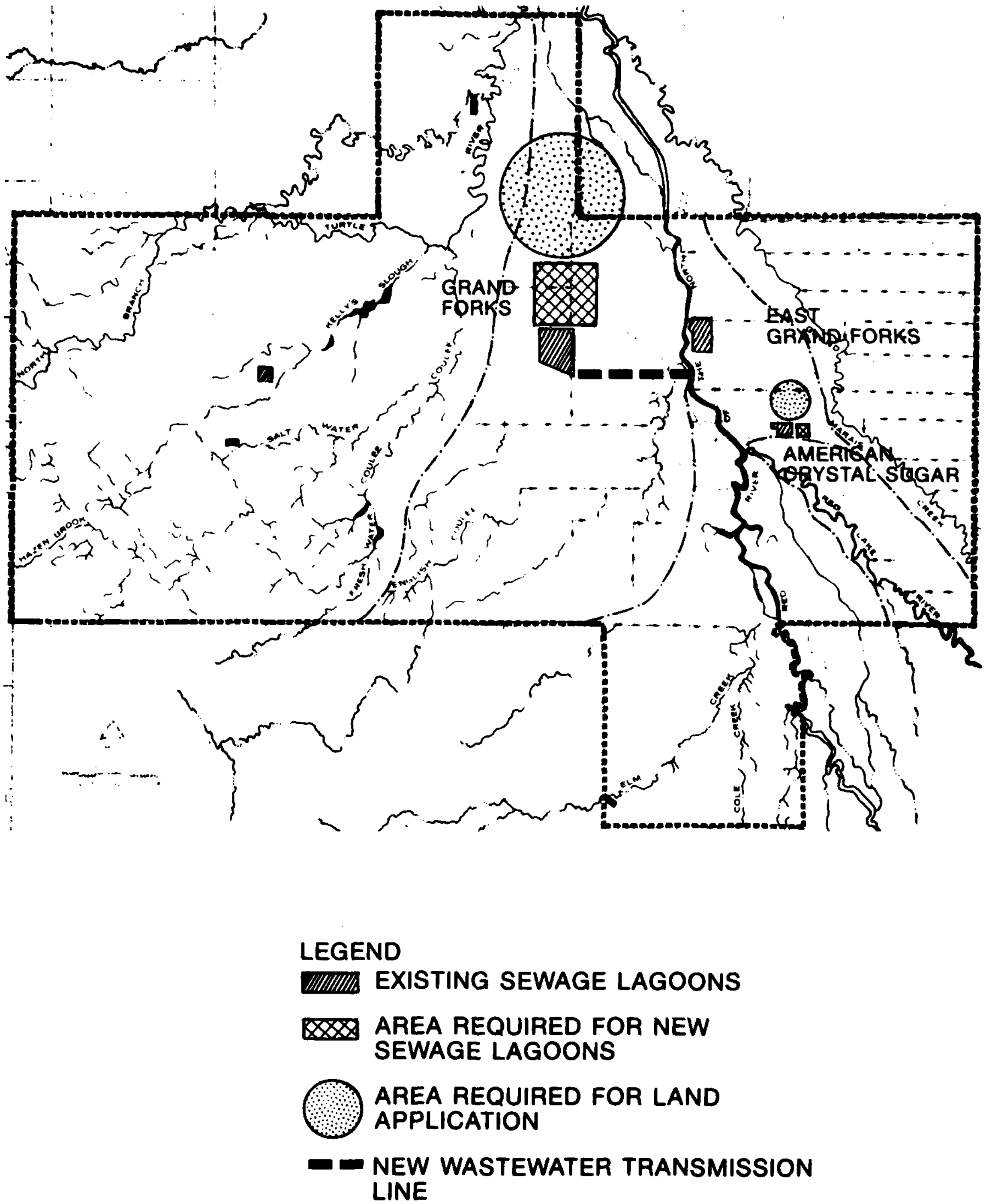


Figure 19 — Wastewater Management Alternative 3

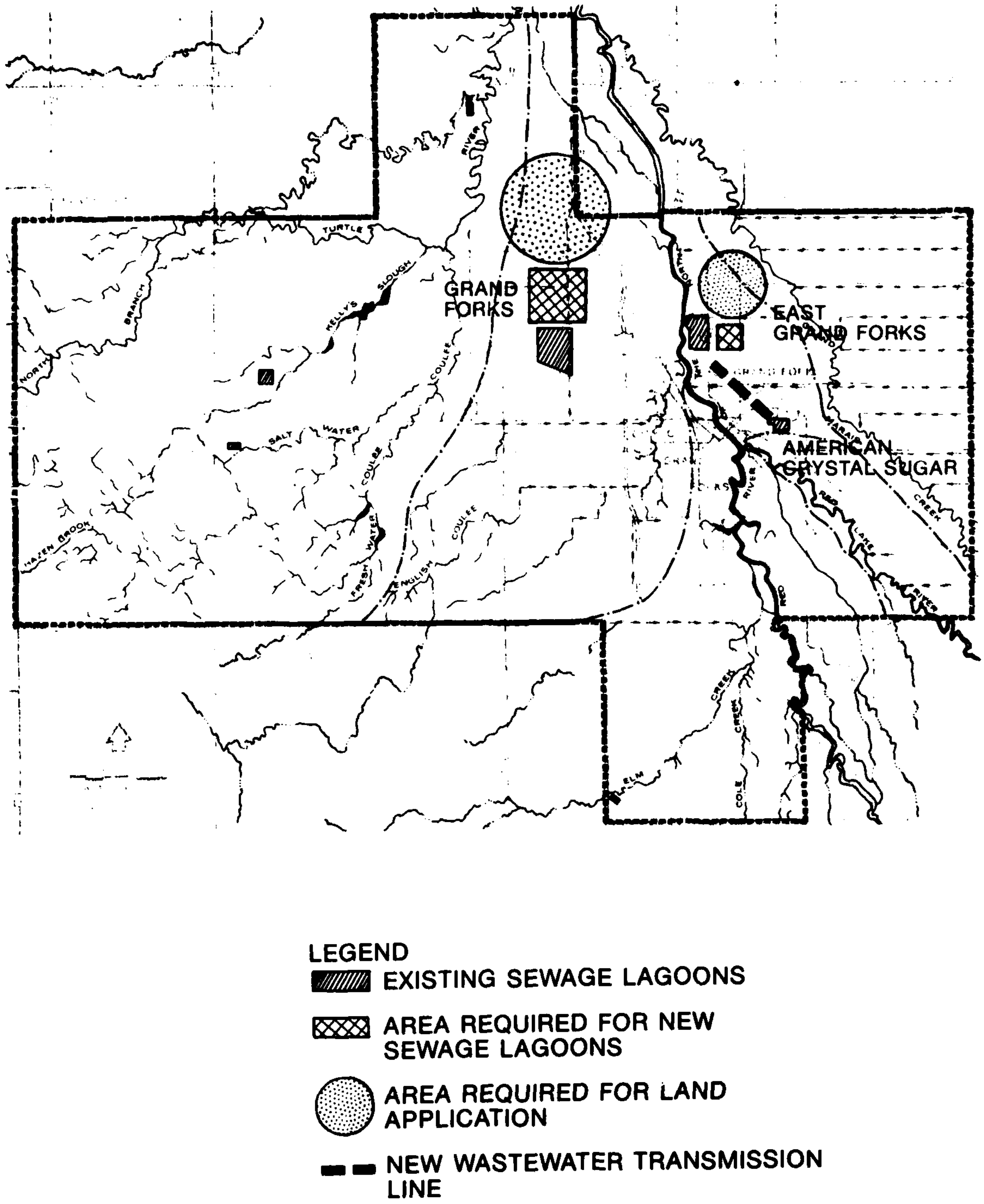


Figure 20 — Wastewater Management Alternative 4

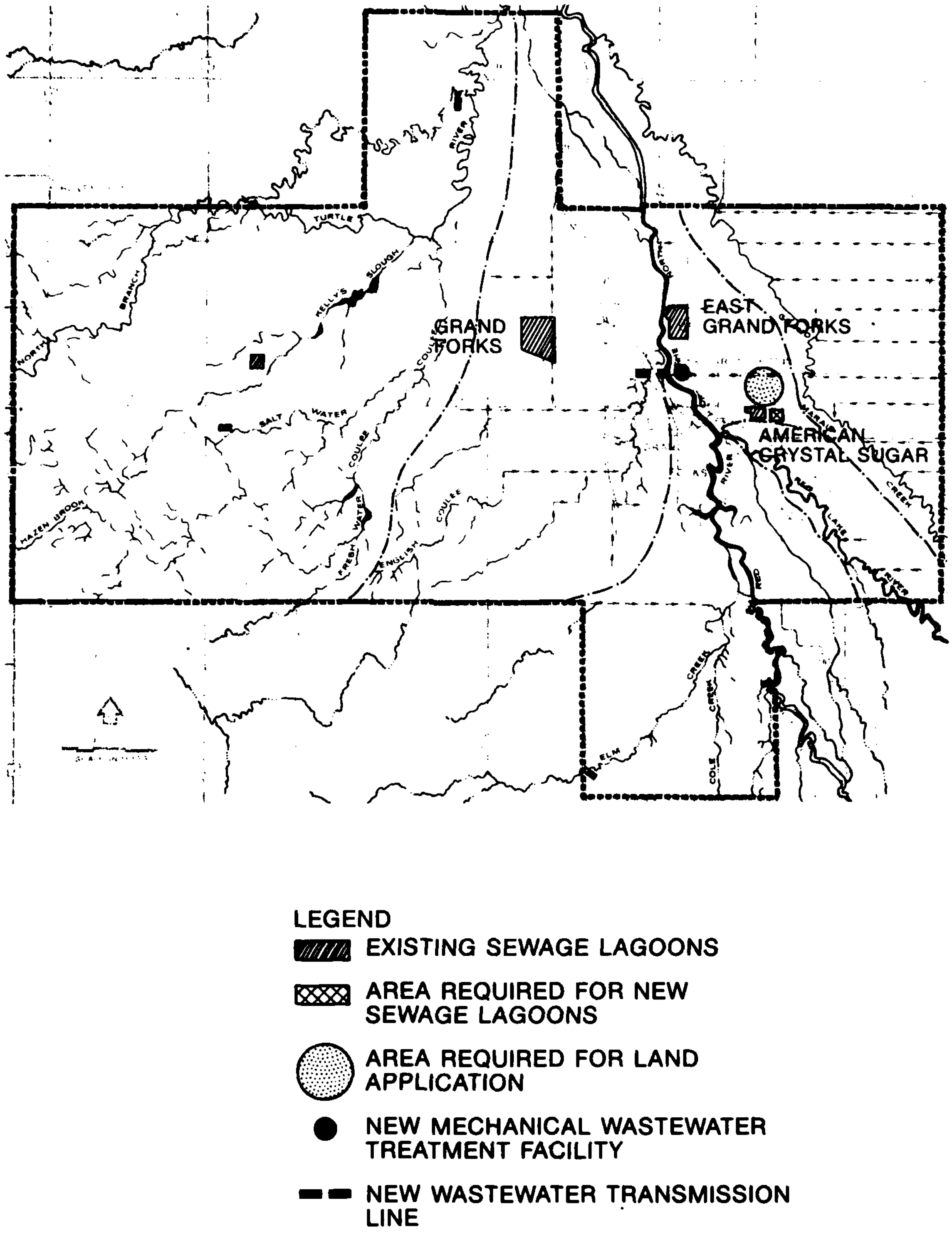


Figure 21 — Wastewater Management Alternative 5

Table 41 - Study area cost summary

GF, EGF, and ACS Alternatives	Equivalent Annual Costs (Thousands of Dollars)											
	Grand Forks (GF)			East Grand Forks (EGF)			American Crystal (ACS)			Total Urban Area Costs	Total Rural Area Costs	Total Study Area Costs
	Capital	O&M	Total	Capital	O&M	Total	Capital	O&M	Total			
1. Lagoon Treatment Separate Systems												
Level I	773	314	1,087	70	135	205	53	62	115	1,407	273	1,680
Level II	773	314	1,087	70	135	205	53	62	115	1,407	273	1,680
Level III	916	392	1,308	106	174	280	200	126	326	1,914	334	2,248
Level IV	1,559	547	2,106	376	219	596	200	126	326	3,028	622	3,650
2. Lagoon Treatment GF, EGF, and ACS Joint												
Level I	831	303	1,134	289	69	358	241	51	292	1,784	273	2,057
Level II	831	303	1,134	289	69	358	241	51	292	1,784	273	2,057
Level III	1,048	389	1,437	330	85	415	268	62	330	2,182	334	2,516
Level IV	1,696	558	2,254	453	118	571	350	83	433	3,258	622	3,880
3. Lagoon Treatment GF and EGF Joint ACS Separate												
Level I	981	365	1,346	188	82	270	53	62	115	1,731	273	2,004
Level II	981	365	1,346	188	82	270	53	62	115	1,731	273	2,004
Level III	1,141	446	1,587	219	98	317	200	126	326	2,230	334	2,564
Level IV	1,857	610	2,467	354	129	483	200	126	326	3,276	622	3,898
4. Lagoon Treatment EGF and ACS Joint GF Separate												
Level I	773	314	1,087	150	86	236	181	57	238	1,561	273	1,834
Level II	773	314	1,087	150	86	236	181	57	238	1,561	273	1,834
Level III	916	392	1,308	232	118	350	235	79	314	1,972	334	2,306
Level IV	1,559	547	2,106	499	195	694	411	129	540	3,340	622	3,962
5. Mechanical Treatment GF and EGF Joint ACS Separate												
Level I	--	--	--	--	--	--	--	--	--	--	--	--
Level II	770	566	1,336	217	160	377	53	62	115	1,828	273	2,101
Level III	920	664	1,584	260	188	448	200	126	326	2,358	334	2,692
Level IV	1,492	1,239	2,731	421	350	771	200	126	326	3,828	622	4,450

pilot studies would be required to demonstrate the feasibility of land application with the soils in the study area.

The present proposals for sewage lagoon expansion in the urban area appear to be adequate until at least 1985. Since the current direction of wastewater treatment, separate facilities based on lagoon systems, appears to be the least cost alternative for the urban area, there does not appear to be a pressing need for additional point source investigations in stage 3 of the urban study.

Other Wastewater Treatment Issues

Other wastewater treatment issues identified previously involve fringe area development using septic systems and odor control at lagoons.

Fringe Area - Rural subdivisions recently developed around the metropolitan area that are served by septic systems. These systems appear to work well if large drainage fields are used. Therefore, an alternative is to relate the allowable use of septic systems to lot size.

If water quality problems exist in areas served by septic systems, one solution is to construct necessary sewers to collect and centrally treat the wastes. This appears necessary at the present time for the area south of Grand Forks, and the city has a sewer master plan for that area.

The use of individual treatment systems for rural homes and subdivisions is in some cases the only practical alternative to centralized wastewater treatment. The groundwater quality should not be seriously affected by these facilities.

Odor Control - Odors are usually a result of putrefaction of the solids in wastewater. The lagoons used in the study area rely on sedimentation and subsequent anaerobic decomposition for solids removal. In addition, significant solids in the form of algae are produced in the lagoons. With spring thaws and circulation of the wastewater, odors are released.

Prechlorination (adding about 9 mg/l chlorine per mg/l sulfide) or preaeration can be used to control odors caused by hydrogen sulfide in mechanical plants. In lagoons, however, natural anaerobic biodegradation of the settled solids will lead to the formation of hydrogen sulfide which may be released to the atmosphere if not oxidized before reaching the surface. The odor control methods applicable to lagoons involve removing the solids, odor making, or provision of sufficient oxygen to reduce anaerobic conditions. Adding lime to raise pH and keep hydrogen sulfide in solution may be an effective and relatively inexpensive solution for odor control during spring thaw of lagoons. It is impractical to collect and treat odorous gases from lagoons.

Efforts should be made to reduce the solids loading on the lagoons or to distribute them more evenly over the lagoon bottom. This should reduce the depth of the anaerobic layer, which will in turn provide a greater potential for oxidation of the odorous compounds as they rise to the surface. In lagoon operation it is important to maintain an adequate depth of wastewaters over the lagoon bottom to prevent growth of rooted plants and to provide a sufficient column of water to adsorb the gases. It must be recognized that occasional periods will exist in lagoons that will lead to odors for which there is no effective control.

Alternative Flow and Load Considerations

The preceding analysis of alternatives is based on the flow and load projections of the section "Point Sources of Water Pollution." Reduction of wastewater flow and load by water conservation programs would generally lower the annual costs of wastewater treatment in the study area.

Increased industrial wastewater pretreatment would have minimal effect on lagoon sizing as total lagoon volume required is more a function of hydraulic load than organic load. Separate industrial waste treatment would lower the load on existing facilities and prolong their life, but this practice is usually not cost effective.

The lagoon system provides a very good flow and load equalization system for the seasonal food processing industries in the study area. Alternative separate industrial facilities would probably be mechanical treatment facilities because of land availability limitations. This type of facility would be extremely difficult to operate because of the seasonal basis of food processing industry. Water conservation programs such as the one being planned at International Co-op would be the most effective means to reduce the cost of joint municipal-industrial wastewater treatment.

A final consideration to be examined for the area is the impact that a major new wet industry would have on the type of treatment facilities used in the area. The existing lagoons at East Grand Forks have the capacity to accommodate an additional flow of about 0.55 MGD by 1990. With the construction of the lagoon additions at Grand Forks, the city will have the capacity to serve an additional flow of about 1.52 MGD. The domestic flow in East Grand Forks is projected to increase 0.35 MGD by 1990 and in Grand Forks would be 1.04. The impact of a new industry would be to require immediate lagoon expansion or would require industrial self-treatment. Water demand projections (21) for the city of Grand Forks included a projection of 1.25 MGD for a new potato industry. If such an industry moved into the city, then the city would need to add 230 acres of lagoons and probably additional pretreatment. This converts to an annual cost increase of about $190,000 for level II treatment at Grand Forks. Clearly, the existing treatment systems do not have the capacity to accommodate a major new wet industry. Additional investigations would be required to determine the degree of expansion needed to serve the wastewater treatment needs of a new industry. For existing industries, expansion may be limited to incorporating production processes that produce no more wastewater than presently produced to avoid the need for immediate lagoon expansion.

URBAN RUNOFF CONTROL ALTERNATIVES

An assessment of the impact on urban intermittent point and non-point stormwater runoff on water quality was made in a previous section. This assessment indicated a need to reduce urban runoff loads with particular emphasis on combined sewer overflows.

Limited information is available on the cost and effectiveness of urban runoff control alternatives. Preliminary estimates of costs and effectiveness are used in this stage of the urban study to identify potential alternative solutions to urban runoff induced water quality problems.

The Environmental Protection Agency has indicated that water quality standards may not be achievable at all times due to the effect of combined and/or storm discharges. Further, the Environmental Protection Agency has indicated that construction grant funds will not be available to fund stormwater treatment and that combined sewers will be treated to much less than secondary treatment levels.

The adoption of a particular alternative is dependent on the water quality and wastewater treatment need being addressed. If the objective is to provide positive control of sewage backing into basements, then combined sewer separation is indicated. If the objective is to reduce coliform loads, then swirl concentrators and high-rate chlorination may be the methods of choice. The greatest reduction in solids loading may occur with increased street sweeping.

The alternatives considered to reduce loads from combined sewer overflow and urban runoff are discussed in the following paragraphs.

Combined Sewer Alternatives

The city of Grand Forks is pursuing a combined sewer separation program. Sewer separation is aimed at resolving problems of basement flooding and certain river water quality problems. The only alternative that appears feasible to prevent the possibility of sewage backing into basements due to overloaded combined sewers in Grand Forks is sewer separation. Individual plugs in homes and businesses can be used to prevent backup at much less cost, but do not provide positive control. Several alternatives are available to

collect and treat or reduce the load on receiving streams from combined sewer overflow.

Alternative A - This alternative consists of sewer plugs. Using a population density of 15 people/acre and an average of three people per home, a total of about 8,500 dwelling units exist in the combined sewer area. At a cost of $300 per home, this alternative would have a first cost of $2,550,000 and an equivalent annual cost of about $200,000. This alternative would not reduce flow or load to the rivers. It is estimated that from 100 to 150 homes per year are affected by basement flooding with one or more incidents occurring with each rainfall event. Major flood events cause backflow in the sewer system and result in a large number of affected residences.

Alternative B - This alternative consists of sewer separation. This alternative would resolve sewer backup problems as well as significantly reduce organic load on the rivers. An extensive study of the sewerage system would be needed to fully delineate this option. Such an investigation is suggested for stage 3 of the urban study.

Using the general construction costs of sewer separation of $12,500 an acre, sewer separation would cost an estimated $26,900,000 (annual cost = $1,922,000). This practice would reduce the after storm BOD_5 load on the river to about 22 mg/l from the previously estimated 45 mg/l. It would also reduce the total nitrogen load to about 2 mg/l from 4.5 mg/l (see table 20). The public health benefits of removing sewage from basements and coliform discharges to the water supply pool in the Red River is a significant factor in this alternative.

Alternative C - The load could be reduced on the river by collection and treatment of the overflows. Very rough costs for a central collection and treatment program for this alternative are presented in table 42. This estimate is based on the construction of a riverfront interceptor to transmit stormwater runoff from the combined sewer area in Grand Forks with subsequent storage and treatment for a 2-hour, 10-year design rainfall. This degree of treatment would reduce after

storm loads from urban runoff to about 25 mg/l BOD_5 and 4.4 mg/l TN. This alternative would not resolve the problem of sewage backing into basements.

Table 42 - Estimated costs to collect and treat combined sewer overflows

	Capital Cost (millions)	O&M ($/year)
Interceptors		
8,000' of 84"	2.46	--
4,000' of 96"	1.35	--
2,000' of 108"	0.90	--
1,200' of 120"	0.46	--
1,300' of 144"	0.96	--
Transport to Storage		
21,000' of 96" FM	9.87	--
Pump Station - 300 MGD, 50' TDH	5.49	18,000
Storage		
100 MG	2.30	35,000
Post Storage Treatment (Q_D = 20 MGD)		
High-Rate Filtration	1.52	40,000
High-Rate Disinfection	0.90	6,000
TOTAL	26.12	101,000

Equivalent Annual Cost = 1,966,000

Source: Stanley Consultants

A collect and treat program in conjunction with sewer plugs would have an equivalent annual cost of $2,166,000, indicating this would be a more costly program than sewer separation to resolve both basement flooding and river quality problems. The treatment provided would not remove as much organic load as sewer separation.

Alternative D - Another option investigated for combined sewer overflows involves use of swirl concentrators and high rate disinfection at existing overflow points. Moderate solids reductions and minor organic load reduction would occur. The major benefit of this option would be a reduction in fecal coliform bacteria, an identified problem with overflows. This option, using cost information from the previous section, would be relatively inexpensive compared to sewer separation and/or collection and treatment options with an estimated annual cost of $250,000.

Urban Stormwater Control Alternatives

Additional pollutant load reduction could be obtained by reducing the load from storm sewers and general urban runoff. One option to do this would be to collect and treat all urban runoff. Based on other studies in the Nation, this option is economically unreasonable in relation to the removal possible. Two options are investigated in this stage of the urban study. Stage 3 analyses should expand on nonstructural control options to reduce urban runoff pollution.

Alternative A - The single most prominant source of pollution from general urban runoff is erosion from construction sites. The cost of various methods of erosion control was outlined in table 35. If it is assumed that some 5,000 acres of land will be developed to serve future urban development needs by 2030 and the cost of erosion control is $5,000/acre, then the cost of requiring construction erosion control would be about $500,000/year. This would result in from 60 to 90 percent reduction of the urban nonpoint load given in table 20.

Alternative B - Most of the load from storm sewers is material deposited on streets and other impermeable urban surfaces. Assuming 25 percent of urban land use is devoted to streets, about 4 square miles of street surface exists in Grand Forks-East Grand Forks. Once per week cleaning would cost approximately $440,000/year. Twice a week would cost approximately $700,000/year. The absolute effectiveness of sweeping streets is dependent on the time that sweeping occurs before

a rainfall event. For illustrative purposes only it will be assumed that once per week sweeping will reduce loads in table 20 by 30 percent and twice a week by 50 percent.

Summary and Conclusions

Results of this preliminary analysis and alternatives considered and their effectiveness in reducing organic and solids loads are summarized in table 43. Cost effectiveness of the various alternatives is given in terms of dollars per year per pound of BOD or TSS removed. Table 43 indicates that of the structural alternatives combined sewer separation is the most cost-effective solution in terms of BOD removal. Nonstructural alternatives of street sweeping also appear cost effective. The assessment conducted in a previous section indicated that BOD_5 concentrations in the Red River of the North may approach 40 mg/l for short periods following rainfall-runoff events of a 10-year frequency at low river flows. This BOD concentration may depress river water dissolved oxygen concentrations below water quality standards for short periods. Combined sewer separation would remove almost 50 percent of the estimated total pollutant load for the typical rainfall-runoff event. In addition, combined sewer separation would also eliminate the backing up of sewage into basements due to overloaded combined sewers. Based on these factors it is recommended that additional investigation in stage 3 should be directed at:

1. Detailed investigations of the combined sewer area in Grand Forks with the objective of developing plans for combined sewer separation.
2. More detailed investigations of the water quality impact of urban runoff and outline of nonstructural control alternatives that can be implemented to reduce urban runoff loads.

Table 43 - Cost and effectiveness of urban runoff control alternatives

Action	Combined Sewers	Storm Sewers	Urban Nonpoint	Annual Cost	$/yr/lb BOD or TSS Removal
	BOD_5 Remaining (lbs)[1]				
No Action	60,000	47,700	20,000	—	—
Combined Sewer Separation	0	47,700	20,000	1,922,000	32
Collect and Treat	24,000	47,700	20,000	1,966,000	55
Swirl Concentrators	57,000	47,700	20,000	250,000	83
Urban Erosion Controls	60,000	47,700	8,000	500,000	42
Once/Week Street Sweeping	42,000	33,400	20,000	440,000	14
Twice/Week Street Sweeping	30,000	23,900	20,000	700,000	13
	TSS Remaining (lbs)[1]				
No Action	212,000	1,004,000	420,000	--	--
Combined Sewer Separation	0	1,004,000	420,000	1,922,000	9.0
Collect and Treat	53,000	1,004,000	420,000	1,966,000	12.5
Swirl Concentrator	170,000	1,004,000	420,000	250,000	6.0
Urban Erosion Controls	212,000	1,004,000	170,000	500,000	2.0
Once/Week Street Sweeping	148,000	703,000	420,000	440,000	1.2
Twice/Week Street Sweeping	106,000	502,000	420,000	700,000	1.1

[1]Values from Table 18 for the no action alternative and the reductions indicated in the text.

Source: Stanley Consultan

IMPACT ASSESSMENT

GENERAL

This section provides a preliminary impact assessment of the wastewater management alternatives and urban runoff control alternatives. Consideration is given to environmental, social, and economic factors.

WASTEWATER TREATMENT ALTERNATIVES

A preliminary impact analysis matrix for the wastewater treatment alternatives is presented in table 44. The major impacts of the lagoon systems are the large areas required for sewage lagoons and land application. Acreages shown in table 44 are to meet wastewater treatment needs to the year 2030. The differences in sewage lagoon acreages between Alternatives 1 through 4 are primarily due to use and/or abandonment of existing lagoons for various regionalization concepts.

Land application is required for level IV treatment and the acres shown are based on 448 acres/MGD of wastewater treated. More detailed studies would be required of soil characteristics in the study area to determine a more precise application rate. Level III treatment requires the addition of sand filters to the lagoons. Areas are not shown for sand filters as they are quite small (about 700 square feet/MGD).

The major differences in impacts between the lagoon system alternatives are in the location of the treatment facilities. Each alternative requires extensive land area. Alternative 1 requires no new wastewater transmission facilities; Alternative 2 requires about 6 miles of transmission lines including a pump station; Alternative 3 requires about 4 miles of transmission line including a pump station; Alternative 4 requires about 2 miles of transmission line. Construction of these new wastewater transmission lines could have an impact on transportation depending on their location.

A better idea of the large land areas involved can be gained from figures 17 through 20. A considerable amount of agricultural land must

Table 44 - Impact analysis matrix - wastewater treatment alternatives

Impact Category	No Action	Alternative 1 Lagoon Systems Separate	Alternative 2 Lagoon Systems EGF, GF, ACS Joint	Alternative 3 Lagoon Systems GF & EGF Joint, ACS Separate	Alternative 4 Lagoon Systems EGF & ACS Joint, GF Separate	Alternative 5 Mechanical System EGF & GF Joint, ACS Separate
Environmental						
Land	Use 967 acres for lagoons	Lagoon Acres = 2,780 Land Application Acres = 7,300	Lagoon Acres = 3,200 Land Application Acres = 7,300	Lagoon Acres = 3,120 Land Application Acres = 7,300	Lagoon Acres = 2,860 Land Application Acres - 7,300	About 30 acres
Man-Made Resources	No effect	No significant effect	No significant effect	No significant effect	No significant effect	Depends on precise location
Natural Resources	No change	Extensive land required	Extensive land required	Extensive land required	Extensive land required	Minimal land required
Water Quality	Water quality standards not met	Water quality standards met	Water quality standards met	Water quality standards met	Water quality standards met	Water quality standards met
Air Quality	No effect	Occasional odor	Occasional Odor	Occasional odor	Occasional odor	Minimal odor
Wildlife	Discharge may negatively affect	Provides waterfowl habitat	Provides waterfowl habitat	Provides waterfowl habitat	Provides waterfowl habitat	Removes existing lagoons
Hydrologic	Returns flow to streams	Land treatment for Level IV removes flow from stream	Land treatment for Level IV removes flow from stream	Land treatment for Level IV removes flow from stream	Land treatment for Level IV removes flow from stream	Returns flow to stream at all treatment levels
Social						
Noise	No effect	No effect	No effect	No effect	No effect	May be increased
Displacement of People	No effect	Could be considerable	Could be considerable	Could be considerable	Could be considerable	Minimal
Aesthetics	Odors probable	Highly visible	Highly visible but one location	Highly visible	Highly visible	Small area, can be secluded
Community Cohesion	No effect	No effect	Separate "image" reduced	Separate "image" reduced	No effect	Separate "image" reduced
Community Growth	Impaired	Increased	Increased	Increased	Increased	Increased
Historical & Archaeological	No effect	Possibly significant	Possibly significant	Possibly significant	Possibly significant	Insignificant
Transportation	No effect	No significant effect	Construction of new sewer line may have temporary effect	Construction of new sewer line may have temporary effect	Construction of new sewer line may have temporary effect	Construction of new sewer line may have temporary effect
Economic						
Property Values	No effect	May have negative impact over broad area	Broad area impact limited to one site	May have negative impact over broad area	May have negative impact over broad area	Negative impact in small area
Tax Revenues	No change	Decrease	Decrease	Decrease	Decrease	No significant effect
Public Facilities	No change	Increase	Increase	Increase	Increase	Increase
Public Services	No change	Increase	Increase	Increase	Increase	Increase
Employment	Reduced	Increased	Increased	Increased	Increased	Increased
Business and Industrial Activities	Impaired	Increased	Increased	Increased	Increased	Increased
Agricultural Land Lost	No additional land lost	Additional 1,800 acres for lagoons, 7,300 acres for land application	Additional 2,570 acres for lagoons, 7,300 acres for land application	Additional 2,490 acres for lagoons, 7,300 acres for land application	Additional 1,890 acres for lagoons, 7,300 acres for land application	About 30 acres

be diverted to wastewater treatment. Land application does have the benefit of some sort of agricultural crop, which was not taken into consideration in the economic analysis.

Most of the wastewater applied in slow-rate land application systems is given off as evapotranspiration. A small percentage may percolate down to groundwater. This could have a significant effect on the flow in the Red River of the North during low-flow conditions. This aspect should be considered in more depth if level IV treatment is required and land application systems are considered.

Wastewater lagoons apparently serve as a resting place for migratory waterfowl. This wildlife benefit would be eliminated if the lagoon system is abandoned for mechanical treatment facilities.

Lagoon systems may decrease tax revenues as large areas of land are converted to public ownership. This effect is relatively insignificant with the mechanical treatment alternative.

Alternative 5, joint mechanical treatment, requires only about 30 acres for level IV treatment and about 15 acres for level II treatment to meet wastewater treatment needs to the year 2030. The site could be screened from surrounding areas and be relatively unobtrusive. With the assumption of a site being available along the Red River just north of East Grand Forks, about 4 miles of wastewater transmission line is required. A mechanical treatment system would require greater amounts of energy and chemicals than the lagoon systems.

URBAN RUNOFF CONTROL ALTERNATIVES

A preliminary impact analysis matrix for urban runoff control alternatives is presented in table 45. Combined sewer separation would have the most beneficial effect of any of the alternatives as it removes the most pollutants (almost 50 percent of the estimated total BOD load of a typical rainfall runoff event) and eliminates basement sewer backup. However, major disruption would occur over a considerable portion of Grand Forks (see figure 9) during sewer separation construction activities. This could seriously impede transportation and might also disrupt certain business activities. Combined sewer overflows are an unsanitary and unsightly occurrence and may be a health hazard under circumstances where people might come in contact with the overflows.

Table 45 - Impact analysis matrix-urban runoff control alternatives

Impact Category	No Action	Combined Sewer Separation	Collection & Treatment of Combined Sewer Overflows	Swirl Concentrations for Combined Sewer Overflows	Construction Site Erosion Control	Street Sweeping
Environmental						
Land	No significant effect	Disruption during construction	Disruption during construction	Disruption during construction	Protects land resources	No significant effect
Man-Made Resources	No significant effect	Some may be affected during construction	Some may be affected during construction	Some may be affected during construction	No significant effect	No significant effect
Natural Resources	No change	No significant effect	Chemicals and energy for treatment	No significant effect	Protects land resources	No significant effect
Water Quality	Occasional D.O. and coliform problems in Red River	Significant improvement	Improvement but less than sewer separation	Improvement primarily in solids reduction and disinfection	Improvement, reduces solids loads	Improvement, reduces solids loads
Air Quality	No change	No significant effect	No significant effect	No significant effect	No significant effect	No significant effect
Wildlife	No change	May improve aquatic life	May improve aquatic life	No significant effect	No significant effect	No significant effect
Social						
Noise	No significant effect	No significant effect	No significant effect	No significant effect	No significant effect	No significant effect
Displacement of People	No significant effect	No significant effect	Depends on precise location of treatment structures	Depends on precise location of treatment structures	No significant effect	No significant effect
Aesthetics	Sewer backup will continue stream quality may deteriorate	Eliminates basement sewer backup	Does not eliminate basement backups	Does not eliminate basement backups	Prevents unsightly erosion	Streets are cleaner
Community Cohesion	No significant effect	May enhance	No significant effect	No significant effect	No significant effect	No significant effect
Community Growth	No significant effect	No significant effect	No significant effect	No significant effect	No significant effect	No significant effect
Historical & Archaeological	No significant effect	No significant effect	No significant effect	No significant effect	No significant effect	No significant effect
Transportation	No significant effect	Major disruption during construction	No significant effect	No significant effect	No significant effect	No significant effect
Economic						
Property Values	Values may decrease in combined sewer area	May increase in combined sewer area	No significant effect	No significant effect	May enhance	No significant effect
Tax Revenues	No significant effect	No significant effect	No significant effect	No significant effect	No significant effect	No significant effect
Public Facilities	No significant effect	No significant effect	No significant effect	No significant effect	No significant effect	No significant effect
Public Services	No significant effect	Increase	Increase	Increase	No significant effect	Increase
Employment	No significant effect	No significant effect	Increases slightly	Increases slightly	No significant effect	Increases slightly
Business & Industrial Activities	No significant effect	No significant effect	No significant effect	No significant effect	No significant effect	No significant effect
Agricultural Land Lost	No significant effect	No significant effect	No significant effect	No significant effect	No significant effect	No significant effect

Combined sewer separation requires a large capital investment, but continuing operation and maintenance costs are low. Collection and treatment of combined sewer overflows, on the other hand, requires a considerable expenditure for chemicals, energy, and other operation and maintenance costs. Collection and treatment will only remove about 60 percent of the BOD in the overflows and therefore will not result in as great an improvement in water quality as separation. Disinfection during collection and treatment and in the swirl concentrator alternative will reduce any health hazards associated with combined sewer overflows.

Construction site erosion control and street sweeping are actions that will significantly reduce solids loading during runoff events and both have beneficial effects from the standpoint of aesthetics.

EVALUATION

GENERAL

Prior sections of this report have identified water quality problems in the study area, formulated alternatives to resolve those problems, and made a preliminary impact assessment of those alternatives. This section provides additional information and summarizes the advantages and disadvantages of each overall water pollution abatement strategy for the area.

WASTEWATER TREATMENT ALTERNATIVES

The basic objectives in wastewater treatment are:

1. Development of alternative wastewater management plans that, when implemented, will allow wastewater treatment facilities to meet existing and future effluent criteria and that those discharges will not cause violations of instream water quality standards.
2. Enhancement of water-related recreation and conservation of fish and wildlife resources.

Water quality investigations have indicated that level II treatment (BOD_5 = 25 mg/l, TSS = 30 mg/l) with current discharges will be adequate to meet 1983 dissolved oxygen goals for fishable and swimmable waters at low river flow in the Red River of the North. As wastewater flows increase with time, higher degrees of treatment (level III or IV) may be required to protect water quality. Each of the five wastewater treatment alternatives has been developed to provide level II, III, or IV treatment. Therefore,each alternative is capable of meeting stream water quality standards, thereby enhancing water-related recreation and conservation of fish and wildlife resources.

The decision as to which is the best alternative to pursue, based on enhancement of recreation and conservation of fish and wildlife resources, is somewhat dependent on the required degree of treatment, however. If level IV treatment is required, the lagoon based systems

will utilize land application. Since effluent is not returned to the stream, but instead is primarily given off as evapo-transpiration, a reduction in streamflow results. The 7-day, 10-year low flow of the Red River is 65 cfs. The year 2000 combined wastewater flow of Grand Forks and East Grand Forks is 13 cfs (8.4 MGD) and the 2030 flow is 23 cfs (14.8 MGD). Removal of this flow from the Red River could have a significant impact on the recreation and fish and wildlife resources of the Red River. Wastewater effluents for level II and III for the lagoon system alternatives and for all three treatment levels for the mechanical treatment alternative are returned to the stream.

Economics

Table 46 presents a summary of urban area wastewater alternative costs to meet wastewater management needs through the year 2030 and cost rankings. Alternative 1, separate lagoon systems, is the least costly alternative at all three treatment levels. Alternative 5, joint mechanical treatment for Grand Forks and East Grand Forks, is the most expensive alternative at all treatment levels.

Regionalization using lagoon systems does not appear to be cost-effective. Alternative 2, lagoon systems with joint treatment, becomes more cost effective when level IV treatment is required as it is the second ranked alternative at this treatment level.

A mechanical treatment system does not appear to be cost effective compared to lagoon systems. Other factors such as the large land areas required for the lagoon systems must also be taken into consideration. The costs for the lagoon system alternatives do include a land cost of $1,200 per acre. If land costs escalate rapidly the economics of lagoon and land application systems could shift more in favor of mechanical treatment systems.

The city of Grand Forks is in the process of implementing a facilities plan that calls for pretreatment, lagoon expansion, and outfall modifications. Federal construction grant funding is immediately available for this alternative which is compatible with Alternative 1, separate lagoon systems.

Table 46 - Urban area wastewater treatment alternative cost summary and ranking

Alternative	Type Treatment	Equivalent Annual Costs, $1,000	Cost Ranking
1. Lagoon Systems - Separate			
Level II	Lagoons	1,407	1
Level III	Lagoons, Sand Filters	1,914	1
Level IV	Lagoons, Land Treatment	3,028	1
2. Lagoon System - EGF, GF, ACS Joint			
Level II	Lagoons	1,784	4
Level III	Lagoons, Sand Filters	2,182	3
Level IV	Lagoons, Land Treatment	3,258	2
3. Lagoon Systems - GF & EGF Joint, ACS Separate			
Level II	Lagoons	1,731	3
Level III	Lagoons, Sand Filters	2,230	4
Level IV	Lagoons, Land Treatment	3,276	3
4. Lagoon Systems - EGF & ACS Joint, GF Separate			
Level II	Lagoons	1,561	2
Level III	Lagoons, Sand Filters	1,972	2
Level IV	Lagoons, Land Treatment	3,340	4
5. Mechanical System - GF & EGF Joint, ACS Separate			
Level II	Activated Sludge	1,828	5
Level III	Activated Sludge, Filtration	2,358	5
Level IV	Activated Sludge, Filtration, Lime Clarification, Ion Exchange, Carbon Adsorption, Post Aeration	3,828	5

Environmental Quality

If no action is taken to expand wastewater treatment facilities for future needs, effluent standards will not be met and water quality will suffer. Each of the proposed alternatives will meet effluent standards and water quality will be protected. As shown in table 44, the lagoon systems require large areas of land. Use of extensive land for wastewater treatment will result in alteration of certain wildlife habitats. This may have an adverse effect on certain terrestrial species, but may also be beneficial as migratory waterfowl may use the sewage lagoons as resting places. Alternative 1, separate lagoon systems, uses the minimum amount of land area for lagoons as it makes full use of existing sewage lagoons. Alternatives 2, 3, and 4 require that various existing lagoons be abandoned, resulting in greater areas required.

Should level IV treatment be required, the land area for land application to meet the needs through year 2030 is estimated at about 7,300 acres. The effects on environmental quality from the use of this much land for wastewater treatment are difficult to assess and should be considered in more detail if land application systems were to be implemented.

The potential adverse effects of streamflow modification as the result of land application have already been discussed.

A joint mechanical treatment system requires only about 30 acres of land for level IV treatment. Occasional odors will occur with lagoons, but odors should not be any problem with a mechanical facility. The effects on environmental quality of such a facility appear negligible. The construction of a joint mechanical treatment system means the abandonment of 967 acres of existing sewage lagoons, which may have an adverse effect on certain wildlife species.

Social Well-Being

The existing sewage lagoons are a noticeable feature of the landscape in the Grand Forks-East Grand Forks area and tripling the area required by 2030 would make them even a more significant feature. If land application is required, the additional agricultural

land lost to wastewater treatment could cause considerable concern to farmers and rural land owners.

All of the regional treatment alternatives require construction of new wastewater transmission lines. Construction activities could temporarily disrupt transportation and may hinder certain business activities. Construction of a new mechanical treatment facility would provide a temporary stimulus to the employment situation in the area. A regional mechanical treatment facility would be less obtrusive than the lagoon systems and could be effectively isolated from the majority of the population.

Regional Development

In order for the region to continue to develop, wastewater management facilities must be provided. All of the developed alternatives meet this need. Whether regionalized wastewater treatment facilities would enhance or hinder regional development is difficult to assess. The regionalized lagoon system alternative would place all of the wastewater treatment facilities in North Dakota with no facilities in the State of Minnesota. This may affect the relative developments in Grand Forks and East Grand Forks. The large land areas required for lagoon systems must be placed far enough away from potential developing areas in order not to hinder their development. A centralized mechanical treatment system would appear to have much less potential for hindering future land development than the lagoon systems.

Institutional

Given the status of Grand Fork's proposed lagoon system expansion, it would be very difficult to change plans and develop and finance a regional treatment facility. Maintaining separate treatment facilities between Grand Forks and East Grand Forks offers the advantage of not changing the administration and management of wastewater services. The local entities which have financed, constructed, and operated wastewater facilities would continue to own, operate, and expand those facilities. No institutional or legal changes are required and local control, local autonomy, and political accountability are preserved.

Disadvantages of separate systems, which also become advantages for a regional system, are the lack of administrative efficiency, fragmentation of regulatory and operating responsibilities, and a potential lack of coordination between growth centers. A regional system would result in the ability to hire higher caliber personnel to administer and operate the system. For instance, instead of needing two treatment plant superintendents, only one would be needed. Higher caliber operating personnel would assure more reliability in meeting effluent standards.

One complicating factor in a regional system for Grand Forks-East Grand Forks is that two separate States would have regulatory control over one facility. Conflicting standards and reporting requirements would have to be resolved.

It should be pointed out that economies of scale and operating efficiencies of a regional facility are taken into account in the cost estimates for the alternatives. Therefore, advantages for regional management largely become a matter of increased reliability and more efficient administration as cost savings are already included in the cost estimate.

Recreational

The implementation of any of the wastewater management alternatives would ensure maintenance of water quality in the Red River of the North so that it can be used for water-related recreation. None of the wastewater alternatives appear to have a significant impact on recreational resources. Land application systems have the most potential for affecting recreation because of the extremely large land areas required. Land used for application of wastewaters would not be available for recreational activities such as hunting and hiking, while existing rural/agricultural land most likely is available for these activities.

Reliability

Regional wastewater treatment systems have the potential for greater reliability because of being able to hire a higher caliber of manager and operators. The lagoon systems offer greater reliability than mechanical systems from the standpoint of equipment

failure. Because of the large storage volume available in the lagoons they can better handle seasonal or fluctuating flows than a mechanical treatment system. Lagoons also have greater flexibility in effluent discharge as they are designed for complete storage of wastewater for 180 days if necessary. The reliability of land application of wastewaters has not been demonstrated for the climatic and soil conditions in the study area.

Conclusions and Recommendations

Based on the evaluation of the developed wastewater treatment alternatives the following conclusions and recommendations are made;

1. For level II and level III treatment, the most cost-effective alternative is Alternative 1, separate lagoon systems. There does not appear to be any advantage associated with regionalized lagoon or mechanical systems significant enough to offset the lowest cost of this alternative and the fact that this is the direction Grand Forks and East Grand Forks are currently proceeding.

   It is therefore recommended that the existing system of separate lagoons be retained and that Grand Forks proceed with lagoon expansion plans.

2. Even though Alternative 1 is the least costly alternative for level IV treatment using land application, there are sufficient unknowns (potential impacts of the large areas required and technical feasibility) to seriously question whether land application systems should be applied in the study area.

   If level IV treatment is required in the future, it is recommended that more detailed studies be conducted to determine the feasibility of land application systems in the study area.

3. Since existing wastewater treatment facilities along with planned expansions will meet the wastewater treatment needs of the study area for the immediate future, it is recommended that no additional investigations of point source wastewater treatment be conducted in the urban area in stage 3 of the urban study.

URBAN RUNOFF CONTROL ALTERNATIVES

The impacts of various alternatives for control of combined sewer overflows and other urban runoff are presented in table 45 and discussed in a previous section. The cost and effectiveness of these alternatives are presented in table 43.

Economics

The costs in terms of $/year/lb BOD removed indicate that combined sewer separation is the most cost-effective structural control alternative. This alternative will remove almost 50 percent of the estimated total pollutant load for the typical rainfall-runoff event. The other structural control alternatives for combined sewer overflows of collection and treatment and swirl concentrators are clearly much less cost effective and do not solve the problem of basement sewer backup as does combined sewer separation.

The capital cost for combined sewer separation is large (an estimated $26,900,000) with O&M costs being minimal. Capital costs for collection and treatment are estimated at $26,120,000 with annual O&M costs estimated as $101,000.

Expenditures for nonstructural controls such as urban erosion control and street sweeping are less, and the cost effectiveness of both controls in terms of $/year/lb TSS removed appear favorable.

Environmental Quality

Control alternatives for urban runoff appear to have mostly positive impacts on environmental quality. Combined sewer separation eliminates health hazards associated with untreated sewage backing up in basements and overflowing to the Red River. Combined sewer overflows enter the Red River above the dam that backs up the water for

the Grand Forks water supply. In spite of the extensive treatment provided by the city of Grand Forks, this is a highly undesirable situation from a health hazard standpoint. The section "Nonpoint and Intermittent Point Sources" assesses the potential impact of urban runoff on stream water quality. A lack of water quality data at high streamflows makes a precise assessment difficult, but it appears that elimination of combined sewer overflows would make a significant improvement in water quality during rainfall-runoff events.

Social Well-Being

The separation of combined sewers would certainly enhance the social well-being of a significant segment of the population of Grand Forks. Cleaner streets as a result of more frequent street sweeping may also enhance social well-being.

A considerable area of Grand Forks would be disrupted during construction activities involved in sewer separation and this may negatively affect transportation and certain business activities.

Regional Development

Implementation of urban runoff controls would have little impact on regional development.

Institutional

No significant institutional changes would be required for implementation of any of the urban runoff control measures.

Recreational

Implementation of urban runoff controls, particularly combined sewer separation, should enhance water-related recreational activities in the study area.

Reliability

Combined sewer separation is obviously the most effective and reliable of the combined sewer alternatives. Collection and treatment and swirl concentrators are subject to equipment breakdowns and improper operation and therefore must be considered less reliable.

Conclusions and Recommendations

Based on the evaluation of urban runoff control alternatives the following conclusions and recommendations are made:

1. Detailed investigations of combined sewer separation in Grand Forks should be made in stage 3 of the urban study. This investigation should result in a plan and detailed cost estimate for proceeding with combined sewer separation.

2. A more detailed investigation should be conducted of the water quality impact of urban runoff, other than combined sewer overflows, to determine the need for nonstructural control alternatives. If the need is demonstrated, a plan for implementation of nonstructural control alternatives should be developed during stage 3 investigations.

ATTACHMENT A

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ATTACHMENT A - REFERENCES

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ATTACHMENT B
COST INFORMATION

This attachment presents cost information for wastewater treatment facilities and wastewater transmission lines. These costs are used to screen alternatives in stage 2 of the urban study.

WASTEWATER TREATMENT

Cost curves for individual treatment processes are presented in this appendix. The curves depict different application processes and can be combined to obtain a cost for each of the liquid waste treatment and sludge handling schematics presented in the appendix. Major design criteria are included on each curve. The cost basis for all curves is October 1977. Various references (56, 57, 58, 78, 79, 80, 81, 82, 83, 84, 85, 86, 87) were used as the basis for system costs. Experience data in the study area are the bases for the stabilization pond cost curve. Various indexes and labor rates used to update other curve information for this report were as follows:

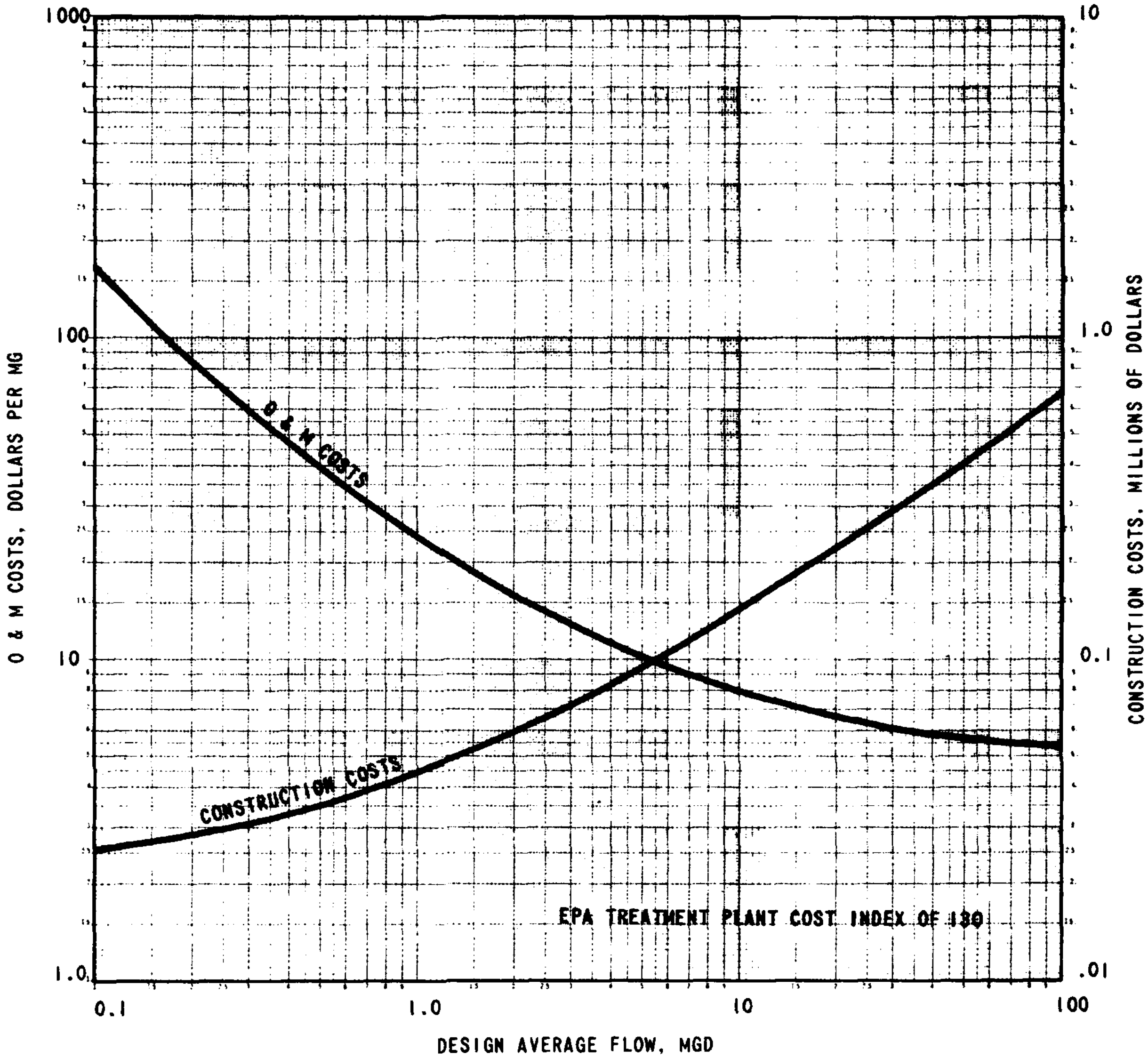
	Index
EPA Sewage Treatment Plant Construction (LCAT) (3rd Quarter 1973 = 100)	130
Engineering News Record Construction Cost	2,500 National

Cost curves for liquid waste treatment processes are presented in terms of cost versus flow for the flow range of 0.1 to 100 mgd. The economy of scale has usually been reached at 100 mgd so that the cost of larger facilities can be estimated by direct proportion to the 100 mgd cost (e.g., a 1,000 mgd plant will cost 10 times as much as a 100 mgd plant and have only slightly lower unit operating cost). The costs of field fabricated small facilities depend on many factors and are not generally subjected to cost curve analysis. The costs for package plants given in the appendix can be used to evaluate probable costs for small facilities (design flow less than 0.1 mgd). Cost curves for sludge handling are provided for dry solids loads between 0.1 and 100 tons per day.

The total cost of a treatment scheme should be obtained by multiplying the total construction cost of unit processes and administration and lab from the cost curves by 1.27 to include other expenses including

engineering, legal, administration, and interest during construction. This total project cost can then be annualized using an interest rate and amortization period. The current interest rate used for cost-benefit evaluation is 6 3/8 percent.

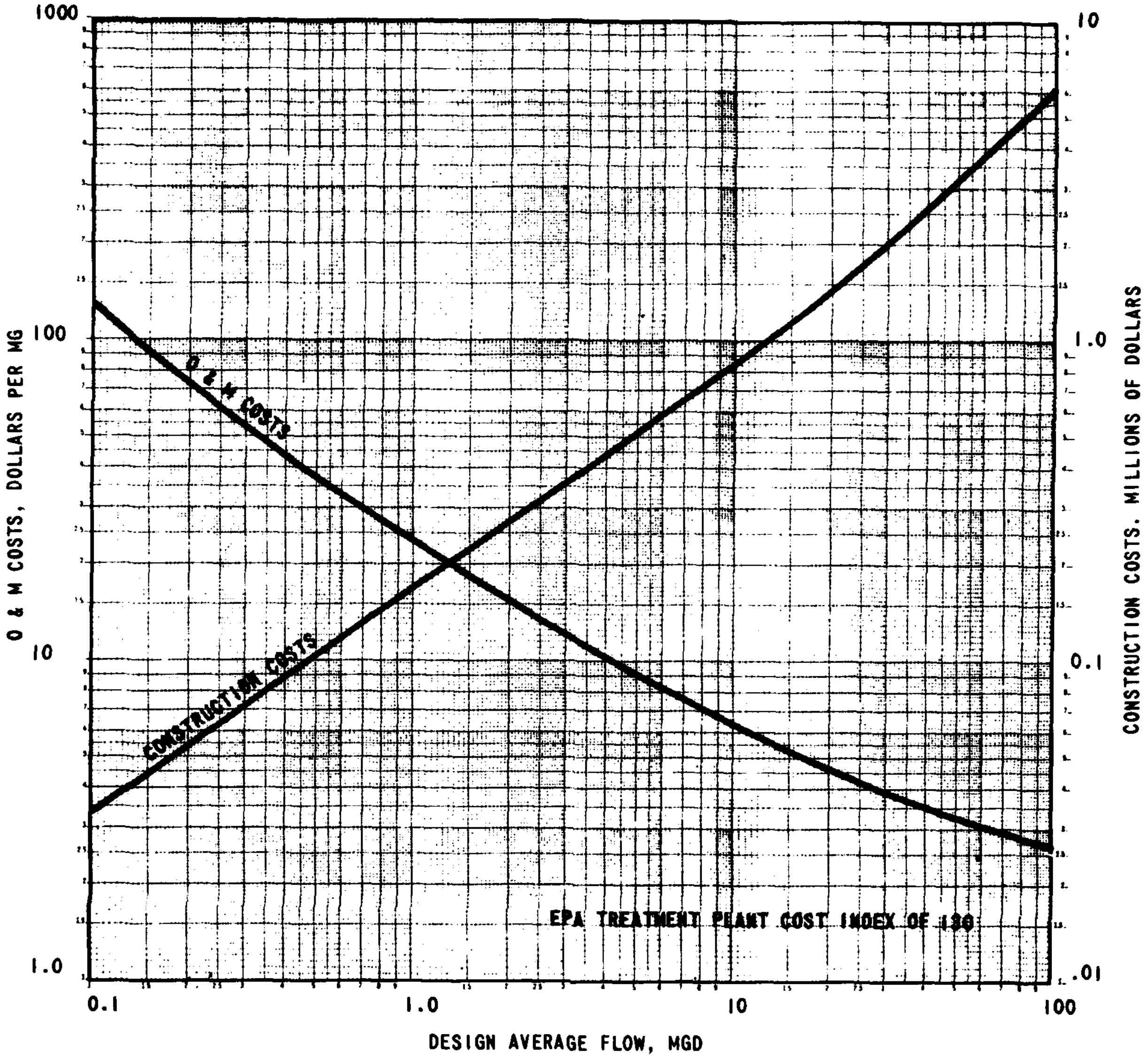
The costs obtained from the curves are sufficiently accurate for preliminary planning only.



PRELIMINARY TREATMENT

COST BASED ON: DESIGN CAPACITY EQUAL TO MAXIMUM FLOW RATE
COSTS INCLUDE: SCREENING, GRIT REMOVAL AND METERING

Figure B-1



RAW WASTE PUMPING

COSTS INCLUDE: VALVES, CONTROLS, WET WELL, DRY WELL AND ENCLOSING STRUCTURE

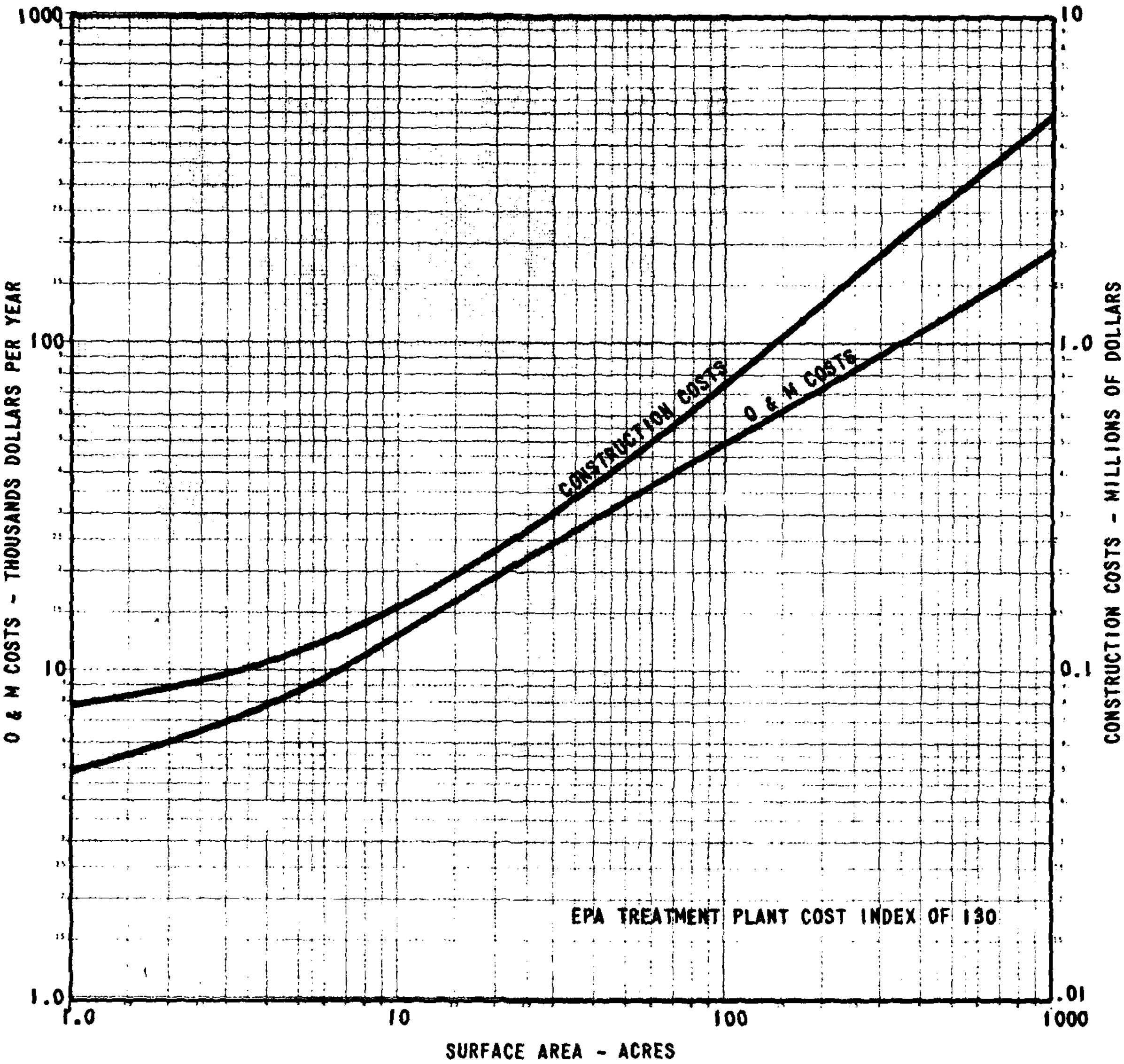
COSTS BASED ON: FIRM PUMPING CAPACITY

AVERAGE FLOW (Q_A) LESS THAN 1 = FIRM CAPACITY 3.33 X Q_A

AVERAGE FLOW (Q_A) BETWEEN 1 & 10 = FIRM CAPACITY 3.00 X Q_A

AVERAGE FLOW (Q_A) GREATER THAN 10 = FIRM CAPACITY 2.25 X Q_A

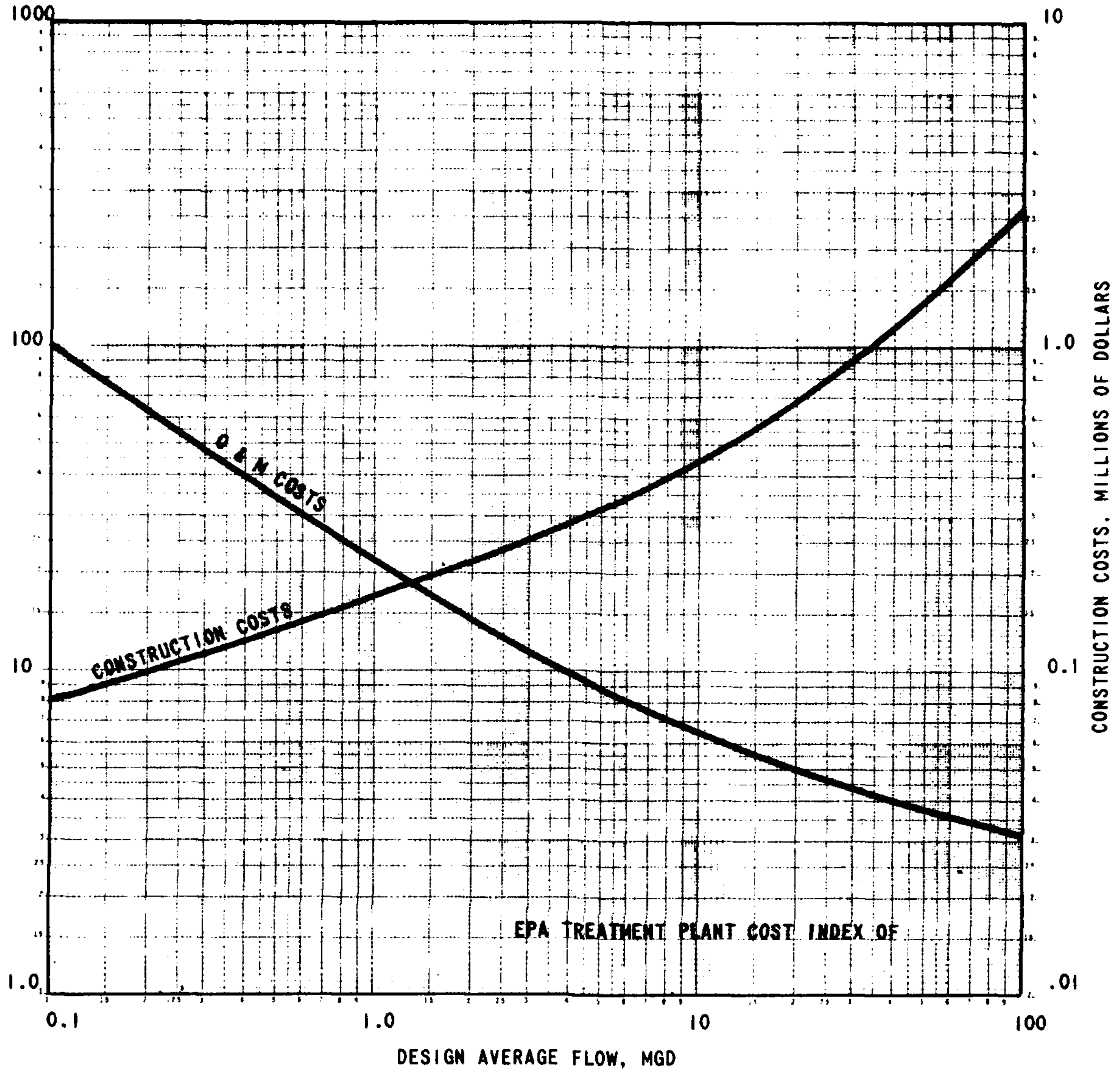
Figure B-2



WASTE STABILIZATION LAGOONS

COSTS BASED ON: 5' WATER DEPTH, 3' FREEBOARD
COSTS INCLUDE: EXCAVATION, BANK PROTECTION, INTERNAL PIPING, FENCING

Figure B-3

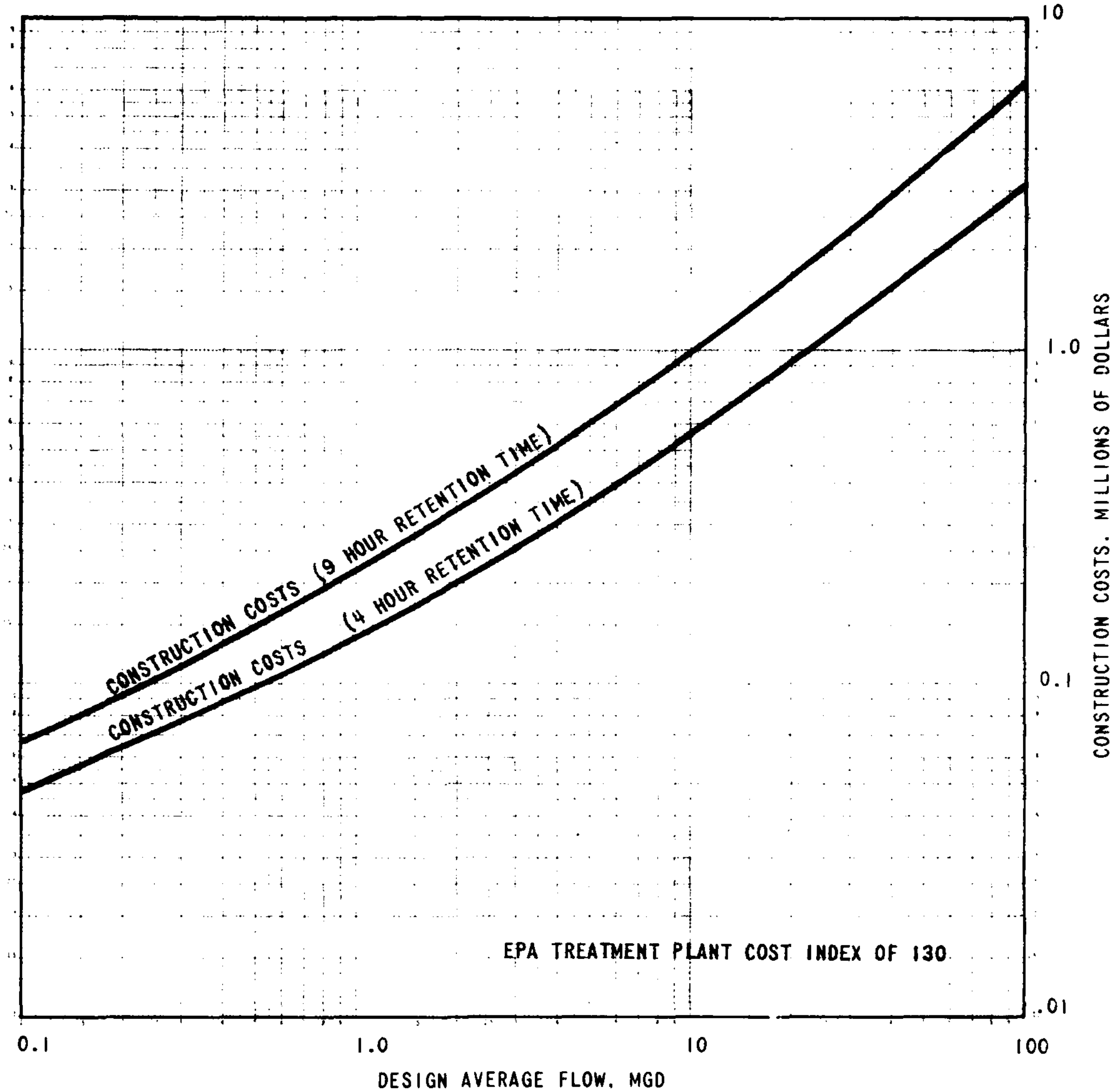


PRIMARY CLARIFIERS

COSTS BASED ON: $Q_A < 1$ SURFACE OVERFLOW RATE 500 GPD/FT^2
$1 < Q_A < 10$ SURFACE OVERFLOW RATE 800 GPD/FT^2
$Q_A > 10$ SURFACE OVERFLOW RATE 1000 GPD/FT^2

COSTS INCLUDE: CLARIFIER, SLUDGE PUMPS

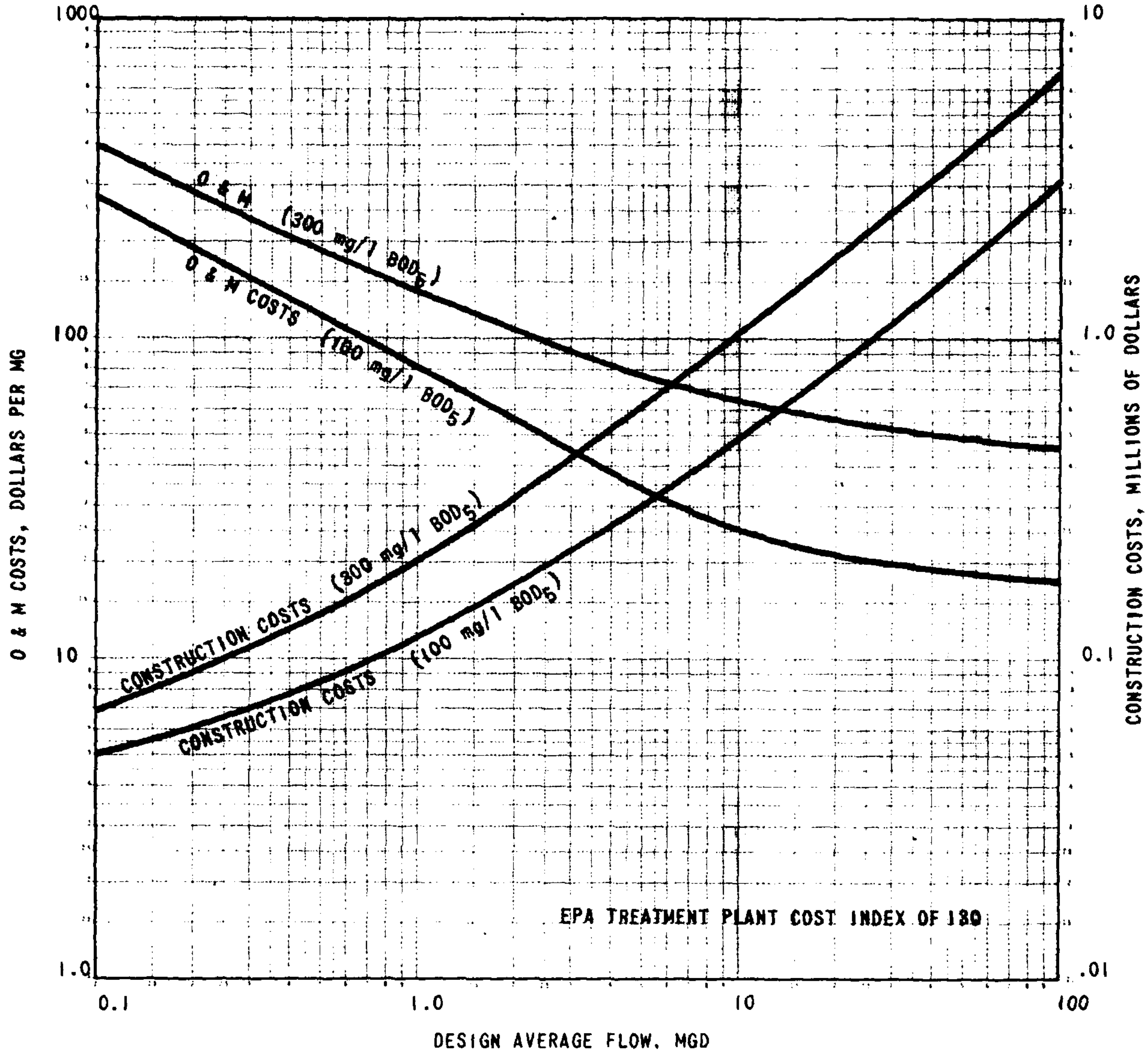
Figure B-4



AERATION TANKS

COSTS BASED ON: AVERAGE DETENTION TIME OF 4 HOURS (CONVENTIONAL ACTIVATED SLUDGE)
AVERAGE DETENTION TIME OF 9 HOURS (FOR SINGLE-STAGED NITRIFICATION SYSTEMS)

Figure B-5

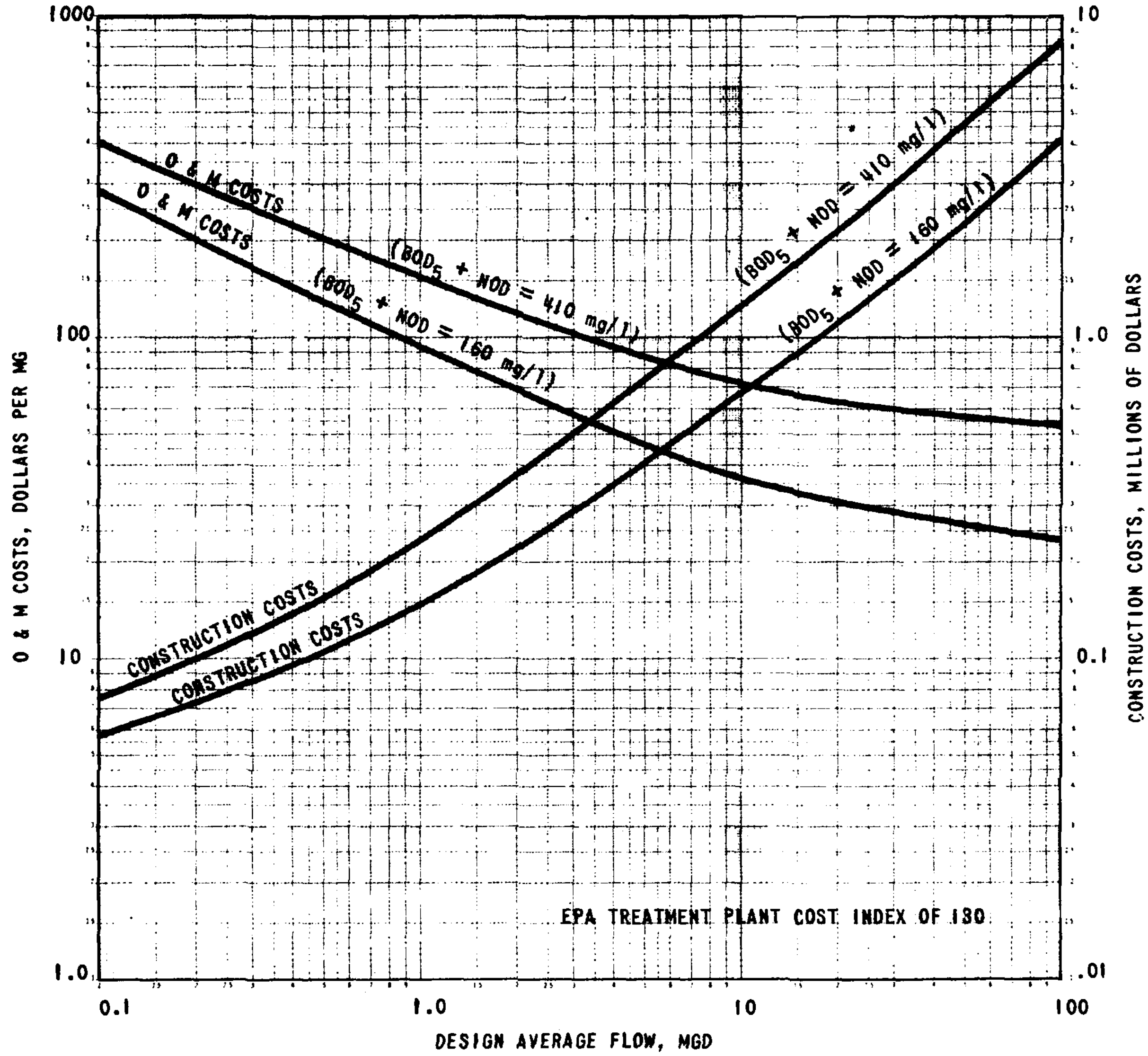


DIFFUSED AIR SYSTEM, CONVENTIONAL ACTIVATED SLUDGE

COSTS BASED ON: 1500 CF AIR/LB BOD_5; BOD_5 = 300 mg/l AFTER PRIMARY
BOD_5 = 100 mg/l AFTER PRIMARY

COSTS INCLUDE: BLOWERS, DIFFUSERS, AIR PIPING & ACCESSORIES, BLOWER BUILDING AND FOUNDATIONS

Figure B-6

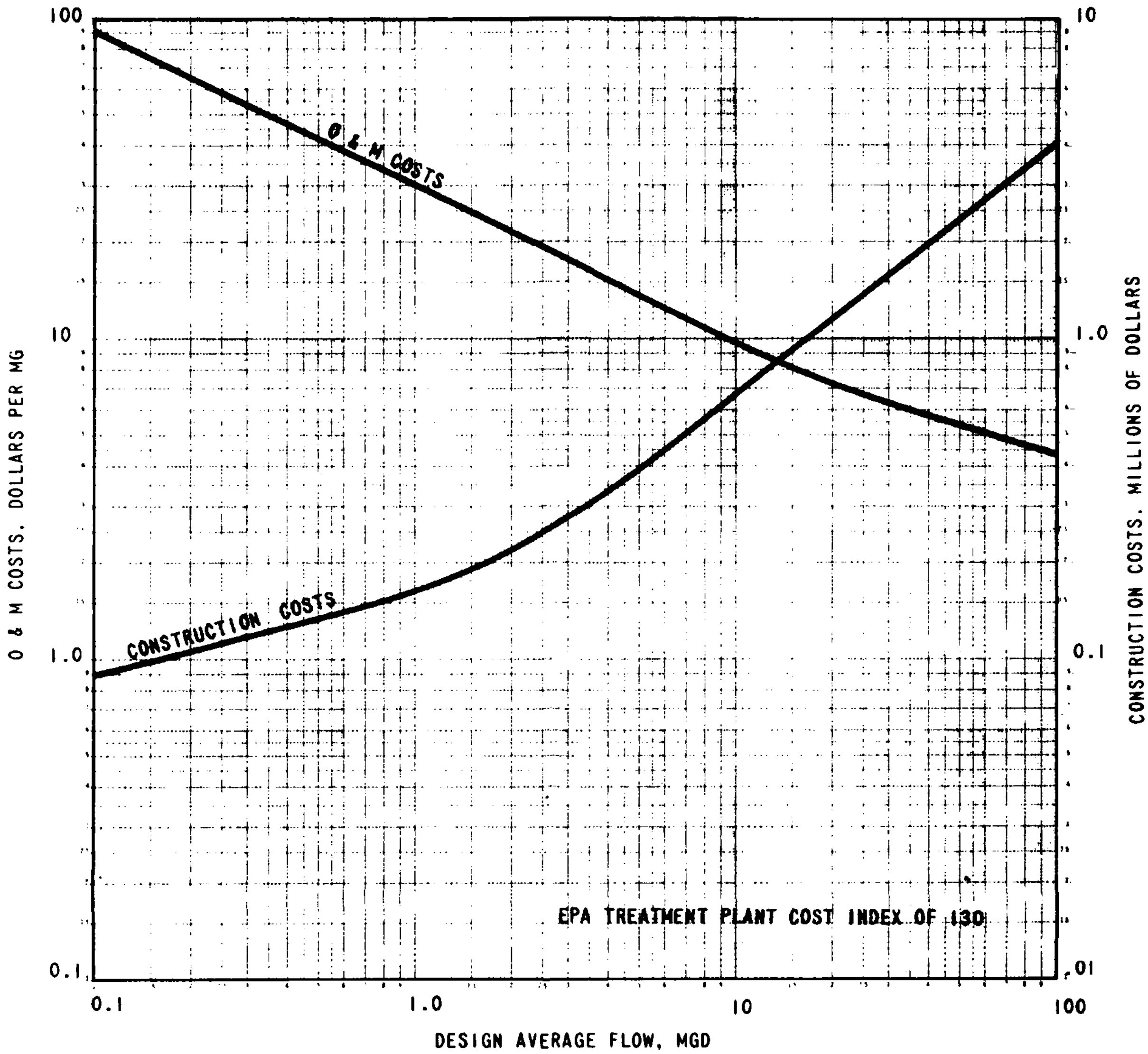


DIFFUSED AIR SYSTEM, SINGLE-STAGE NITRIFICATION SYSTEMS

COSTS BASED ON: 1300 CF AIR/LB (BOD_5 + NOD): BOD_5 + NOD = 160 mg/l AFTER PRIMARY
BOD_5 + NOD = 410 mg/l AFTER PRIMARY

COSTS INCLUDE: BLOWERS, DIFFUSERS, AIR PIPING & ACCESSORIES, BLOWER BUILDING AND FOUNDATIONS

Figure B-7

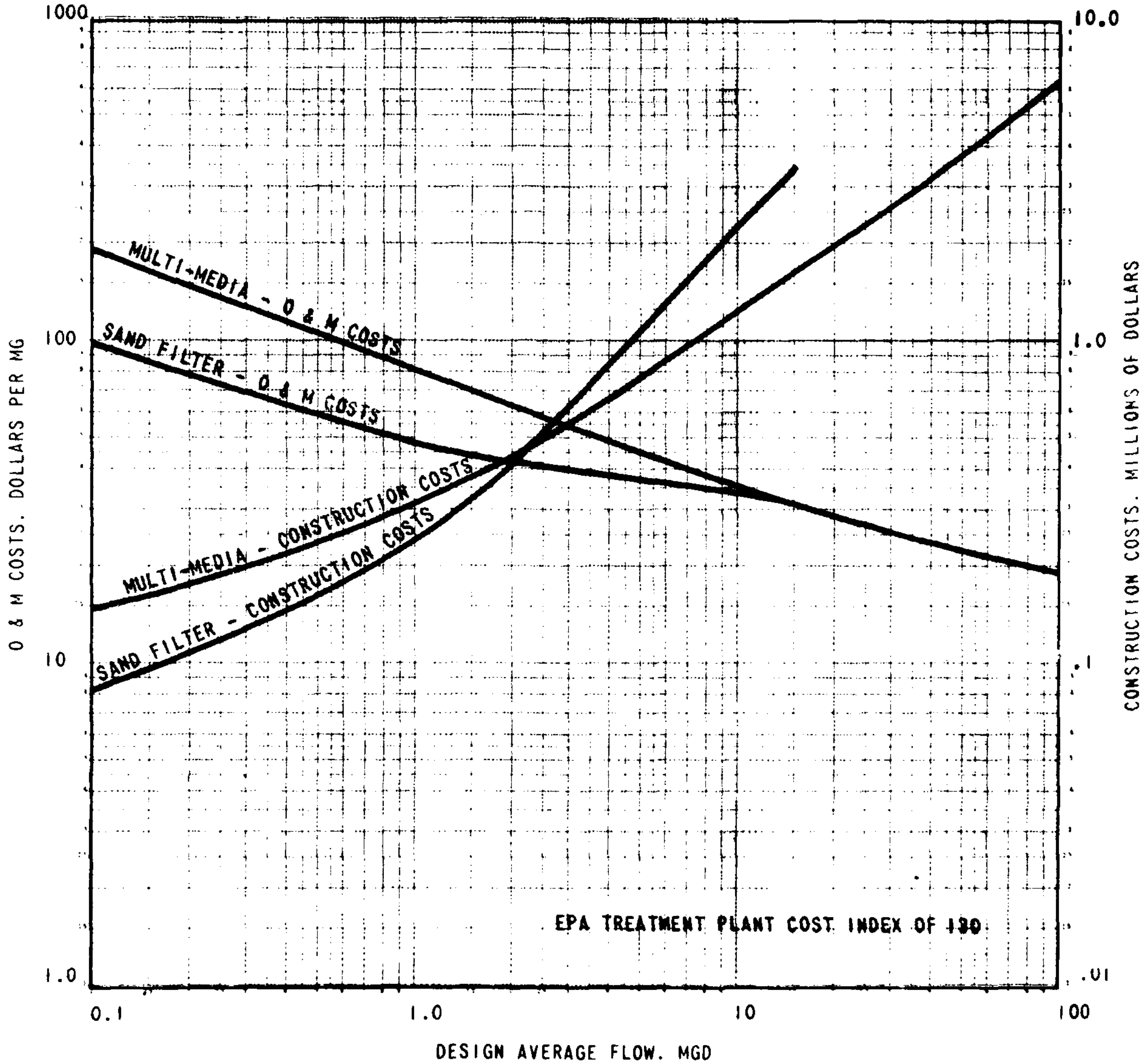


FINAL CLARIFIERS

COSTS BASED ON: SURFACE OVERFLOW RATE = 500 GPD/FT^2 IF $Q_A < 2.0$
SURFACE OVERFLOW RATE = 800 GPD/FT^2 IF $Q_A > 2.0$

COSTS INCLUDE: RETURN SLUDGE PUMPING

Figure B-8

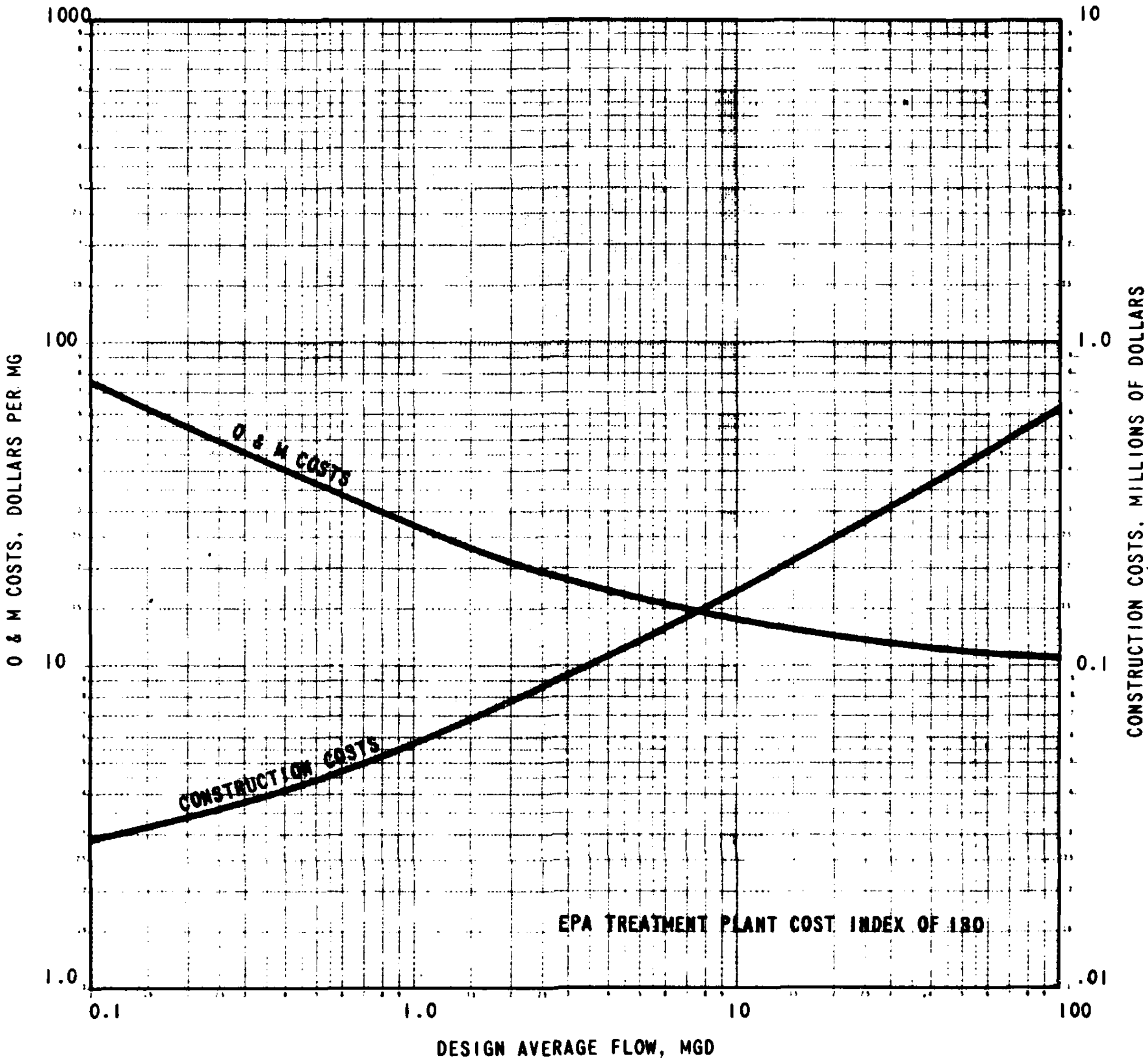


EFFLUENT FILTRATION

COSTS BASED ON: MULTI-MEDIA FILTRATION RATE OF 4 GPM PER SQ. FT.
INTERMITTENT SAND FILTER 1 GPM PER SQ. FT.,
8-DAY DETENTION TIME IN EACH CELL

COSTS INCLUDE: BASINS, EMBANKMENTS, HYDRAULIC WORKS

Figure B-9

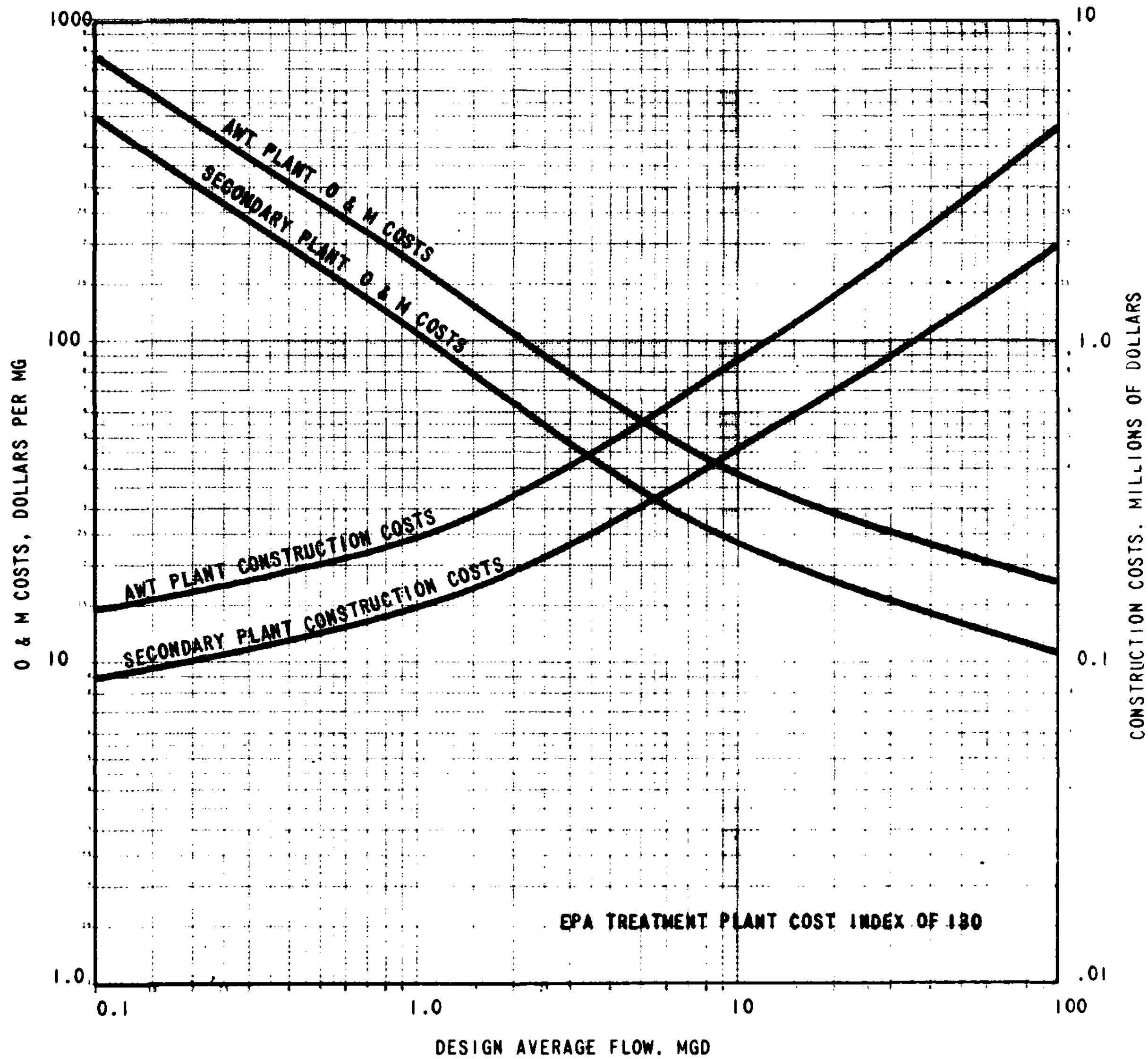


CHLORINATION

COSTS INCLUDE: CHLORINE CONTACT TANK & CHLORINE FEED SYSTEM

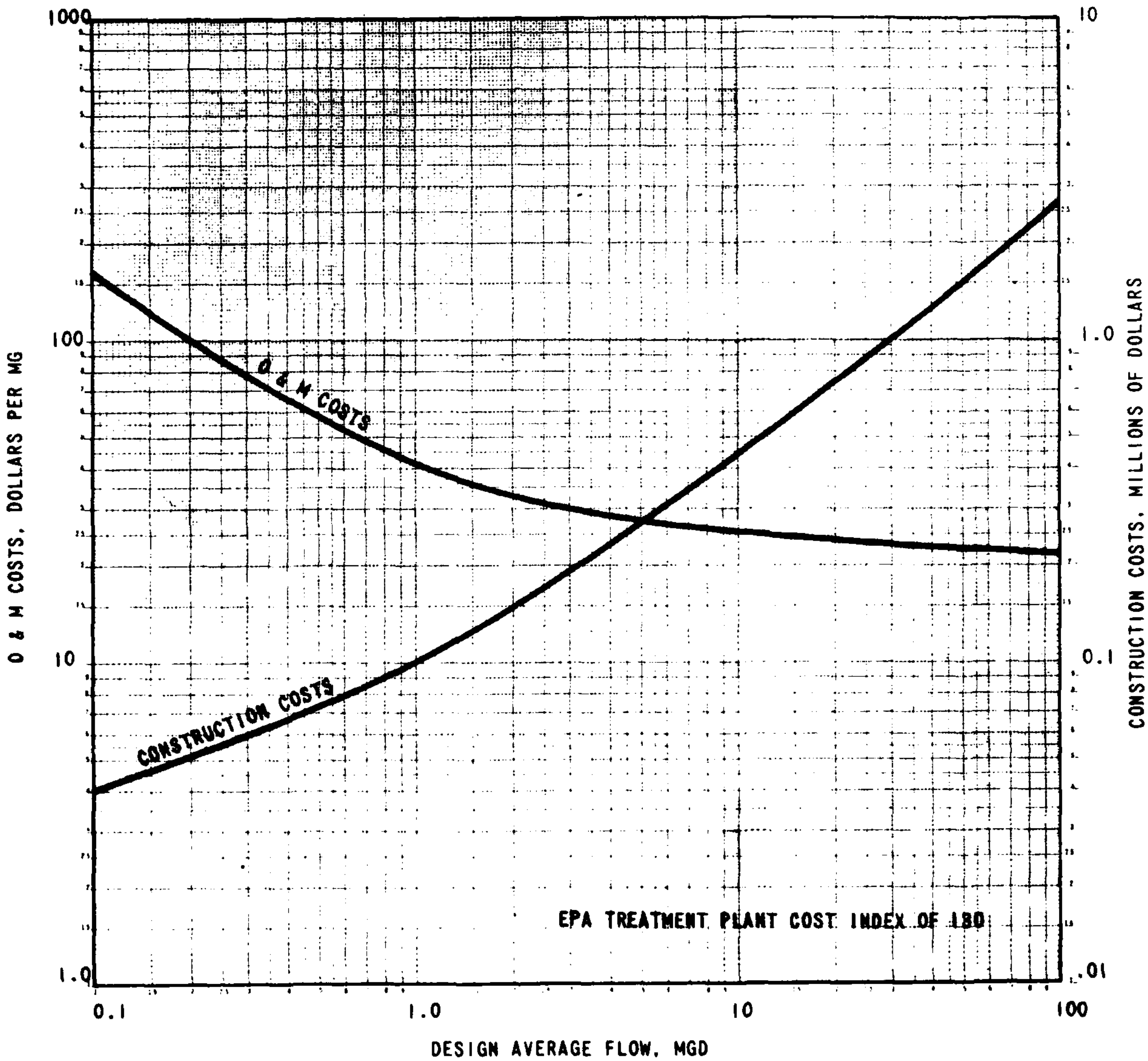
COSTS BASED ON: DETENTION TIME OF 15 MINUTES AT 4-HOUR PEAK FLOW
CHLORINE DOSAGE OF 12 mg/l OF CL_2 AT AVERAGE FLOW

Figure B-10



ADMINISTRATION & LABORATORY FACILITIES,
GARAGE & SHOP AND YARDWORK

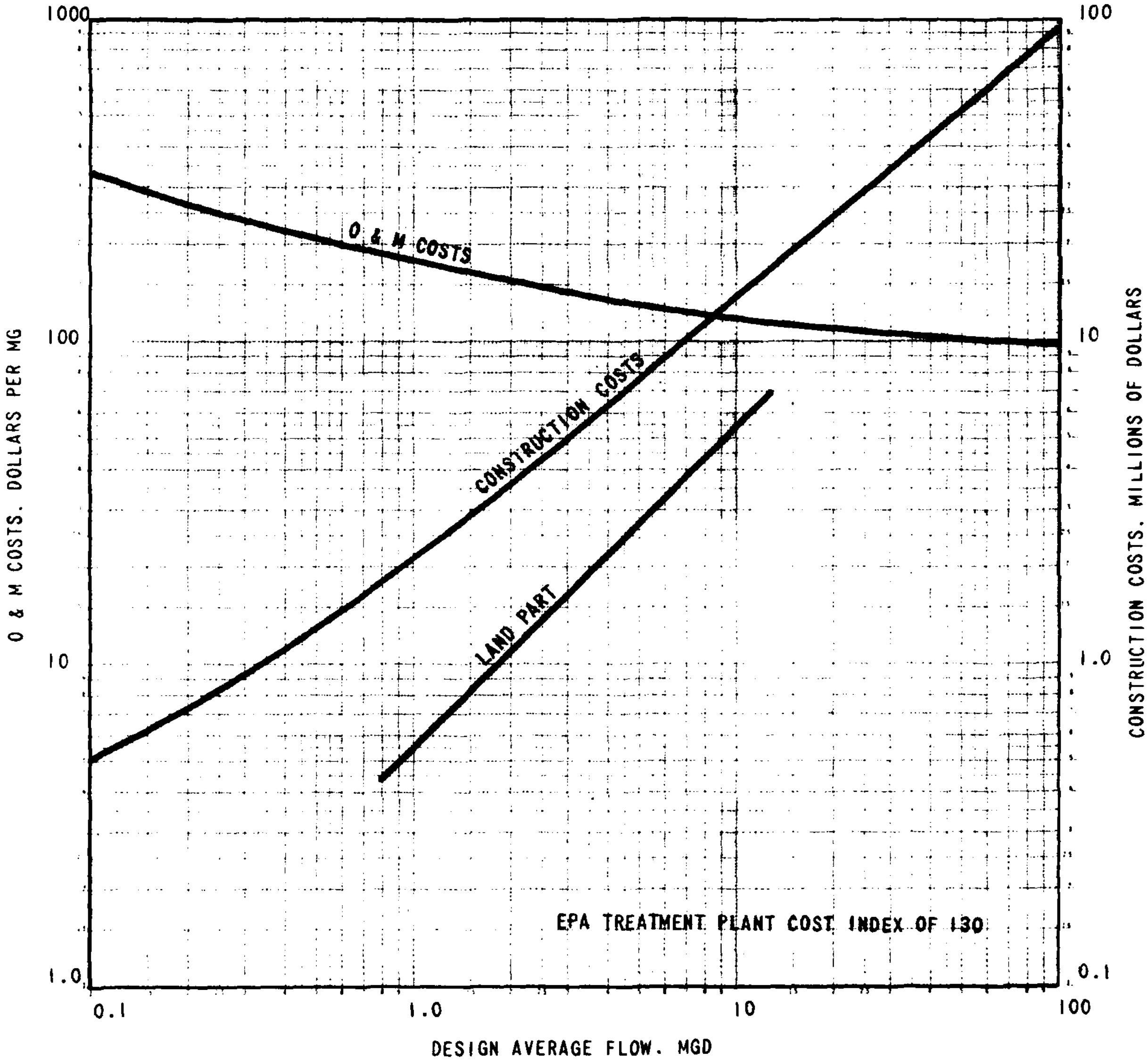
Figure B-11



AERATED LAGOONS

COSTS BASED ON: DETENTION TIME 7 DAYS, 15 FOOT DEPTH
COSTS INCLUDE: BASIN, EMBANKMENTS, AERATION EQUIPMENT (FLOATING OR BOTTOM TUBE AERATION)

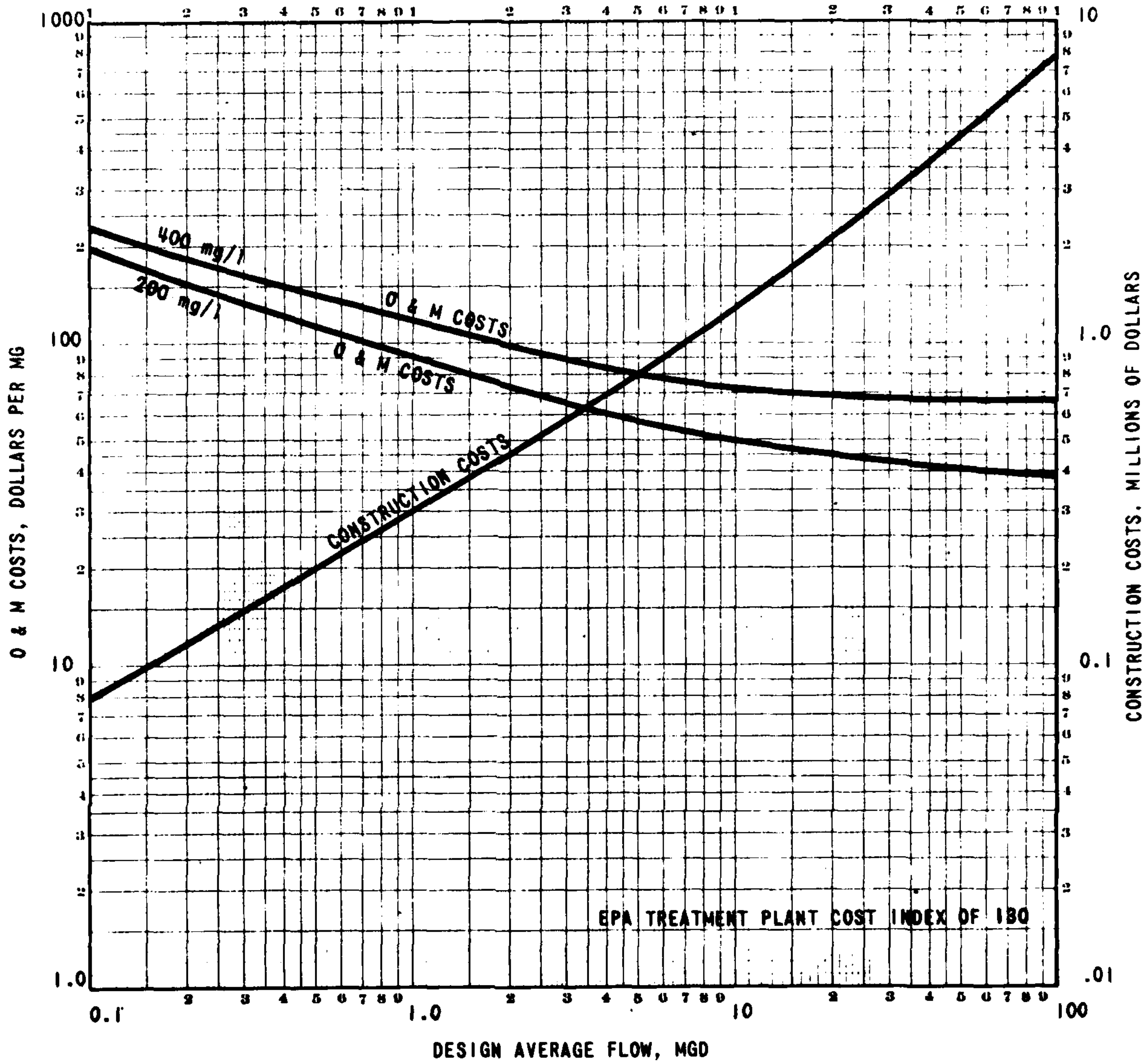
Figure B-12



LAND APPLICATION, TYPICAL SITE

NOTES:
1. BASED ON PRIOR CURVES WITH:
   50% OF FLOW TO HAY AT 48"/YR, NO UNDERDRAINS, CENTER PIVOT
   25% OF FLOW TO CROP AT 30"/YR, UNDERDRAINS, SOLID SET (BURIED)
   25% OF FLOW TO CROP AT 30"/YR, UNDERDRAINS, SOLID SET (ABOVE GROUND)
2. COSTS INCLUDE LAND COST AT $1200/ACRE.
3. COSTS DO NOT INCLUDE PRETREATMENT OR STORAGE, TRANSMISSION, OR PUMPING TO APPLICATION SITE.

Figure B-13

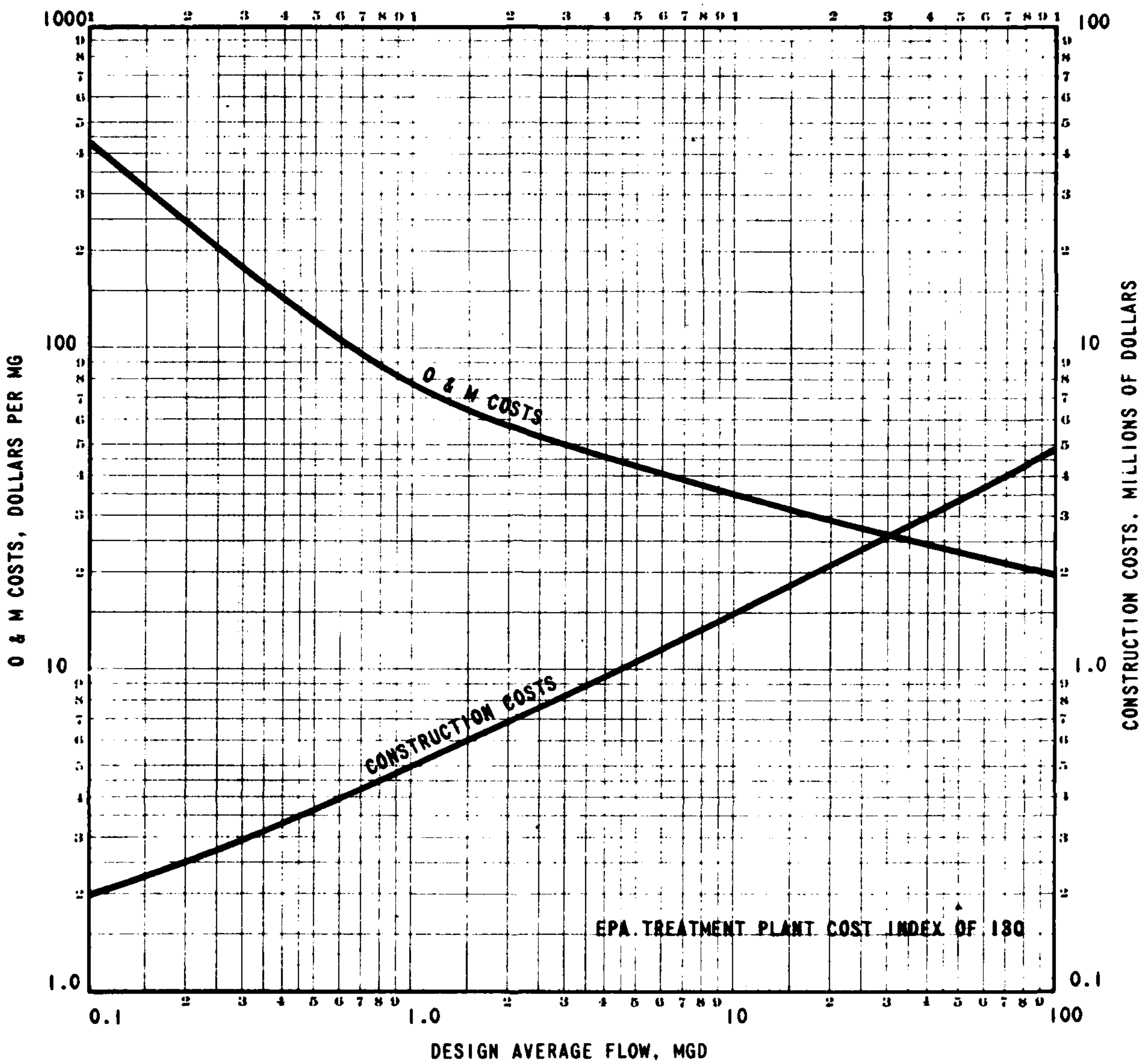


TWO STAGE LIME CLARIFICATION

COST BASED ON: 1. *LIME DOSAGE AS SHOWN.*
2. NO RECALCINATION FACILITIES.
3. SURFACE OVERFLOW RATE OF 1000 GPD/FT^2.

COSTS INCLUDE: TWO MIXING, FLOCCULATION AND CLARIFIER UNITS, CHEMICAL STORAGE AND FEED EQUIPMENT, AND RECARBONATION FACILITIES.

Figure B-14



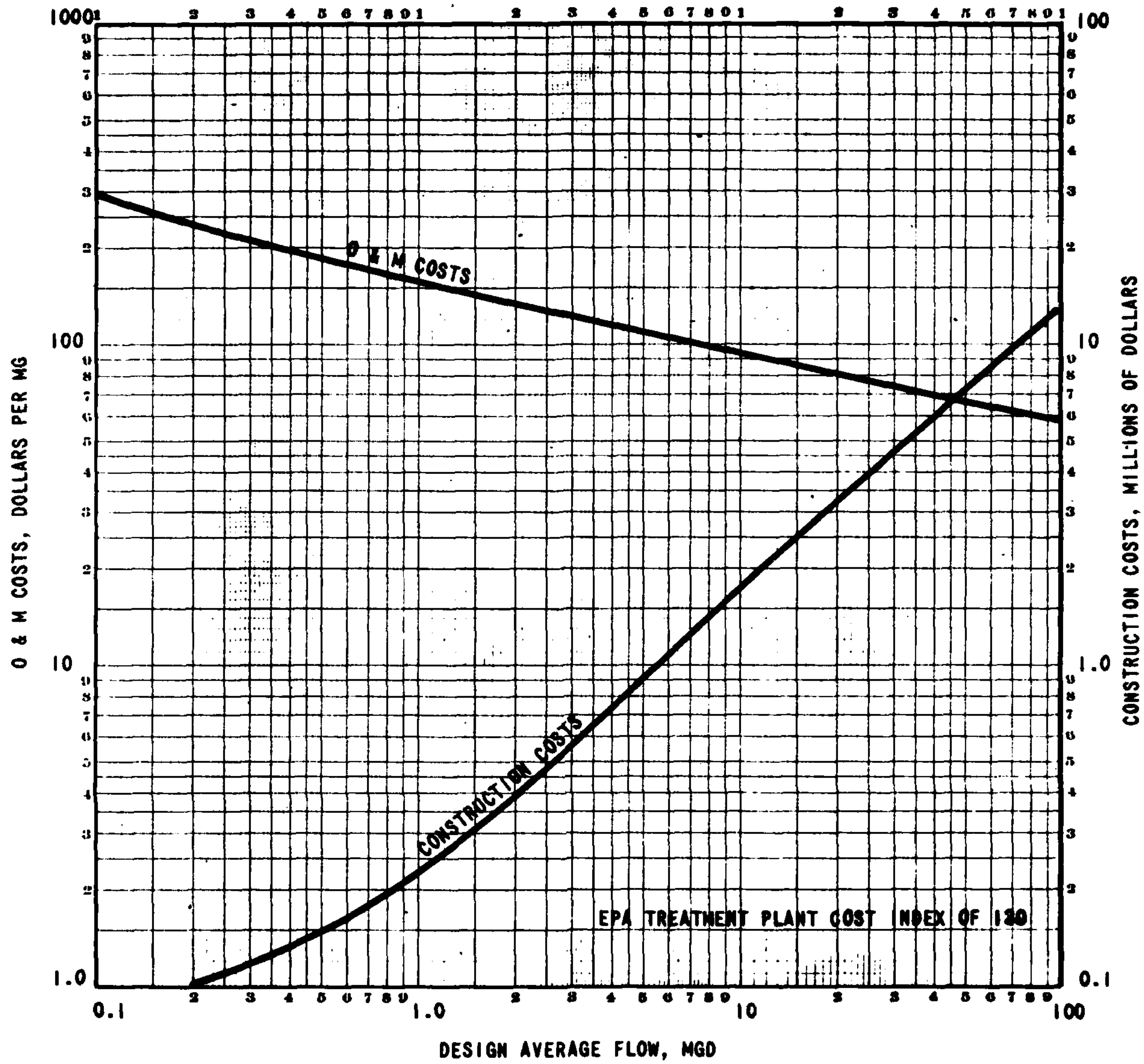
LIME RECALCINATION

COST BASED ON: 1. FURNACE FEED OR 1,000 LBS/HR OF 35% LIME SLUDGE INCLUDING IMPURITIES.

2. 3400 LB/MG LIME SLUDGE PRODUCED

COSTS INCLUDE: LIME SLUDGE THICKENING & DEWATERING.

Figure B-15

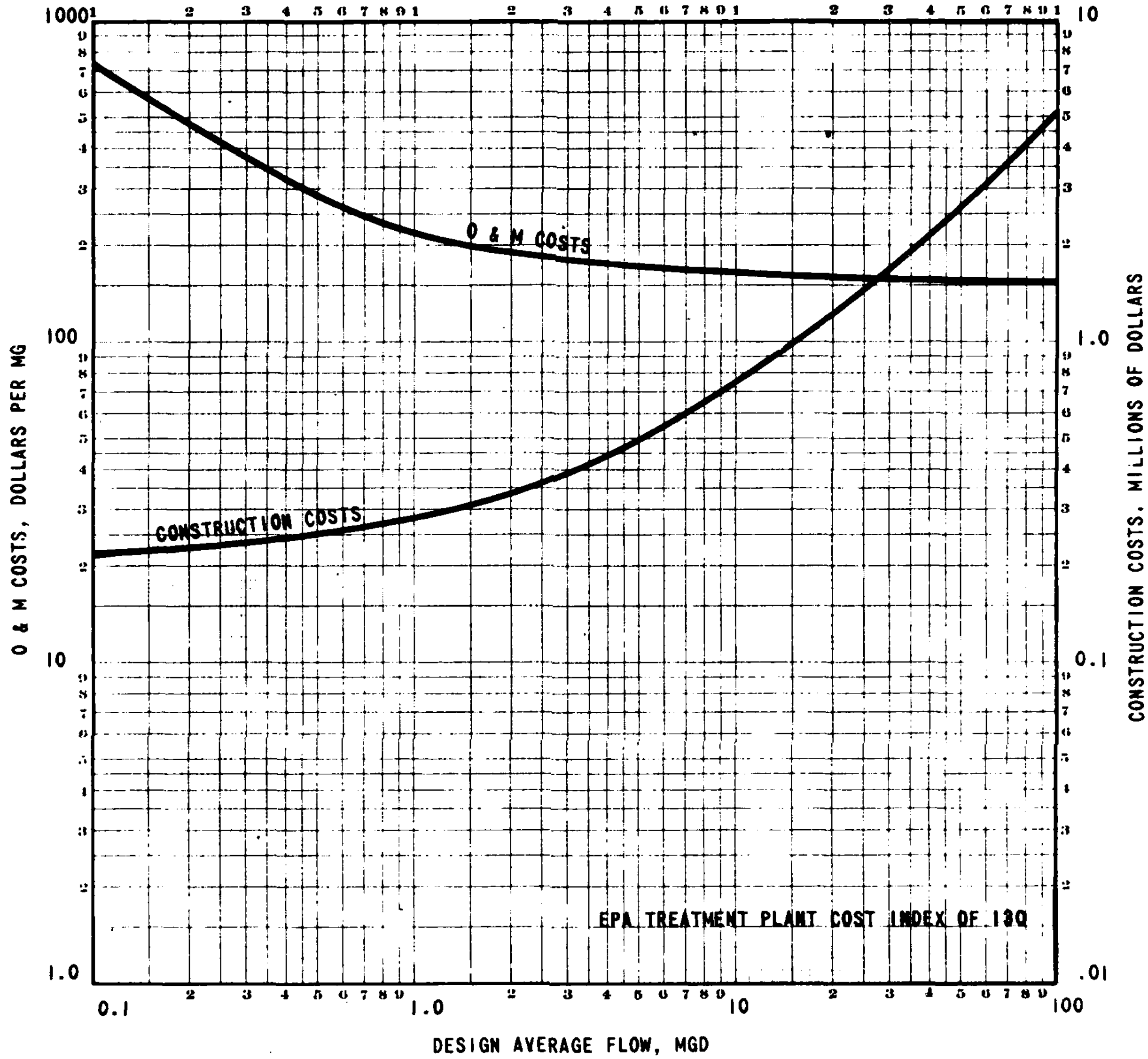


ION-EXCHANGE AMMONIA REMOVAL

COSTS INCLUDE: CLINOPTILOLITE REGENERATION WITH ENCLOSED AIR STRIPPING.

COST BASED ON:
1. FLOW OF 1.5 GPM/FT^2.
2. REGENERATION OF 450 LB PER MG.

Figure B-16

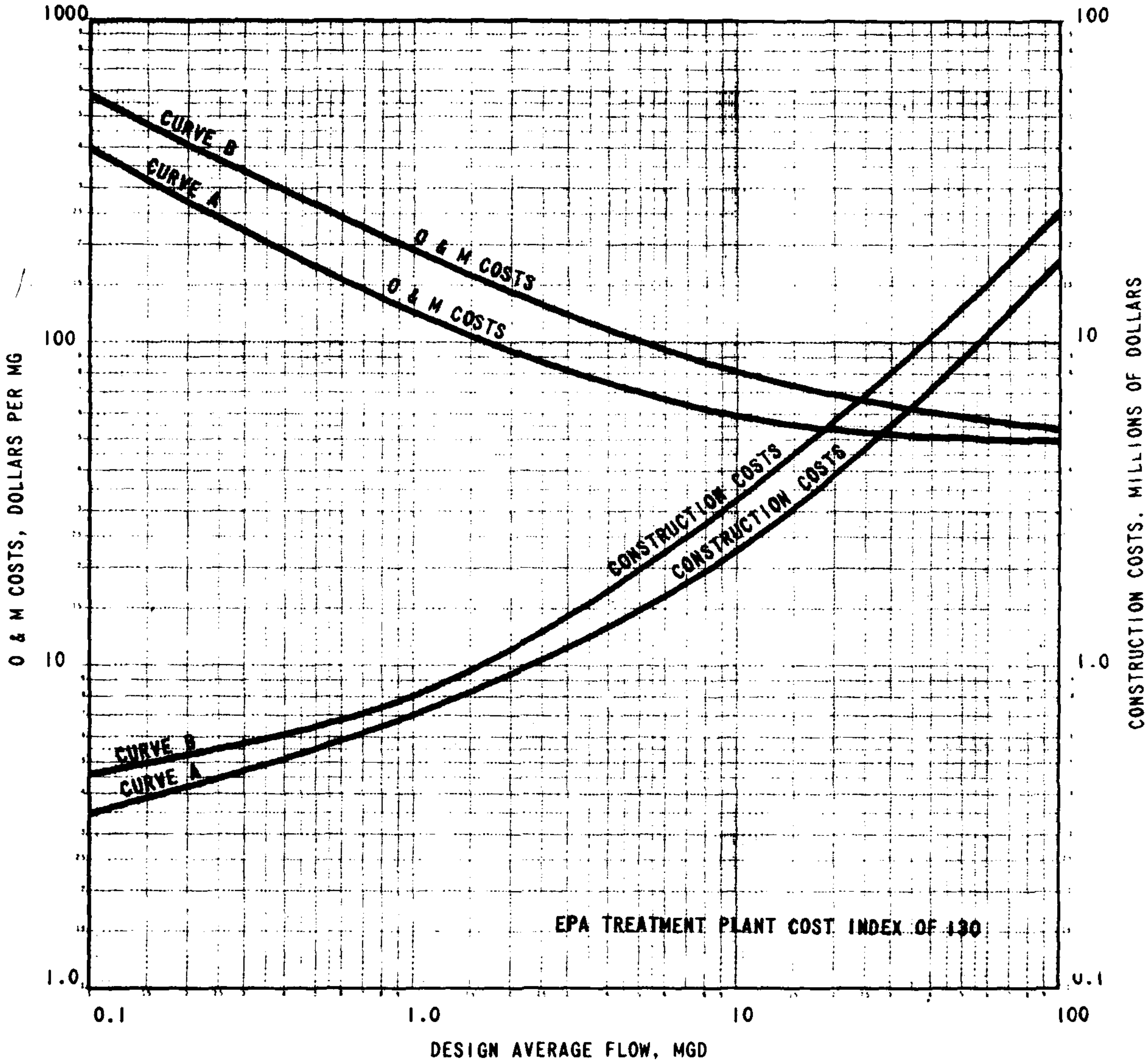


BIOLOGICAL DENITRIFICATION

COSTS INCLUDE: DENITRIFICATION TANKS, METHANOL FEED EQUIPMENT, FINAL CLARIFIER.

COSTS BASED ON: 1. 4.5 LBS METHANOL/LB NO_3.
2. DETENTION TIME 2 HRS.

Figure B-17



GRANULAR CARBON ADSORPTION

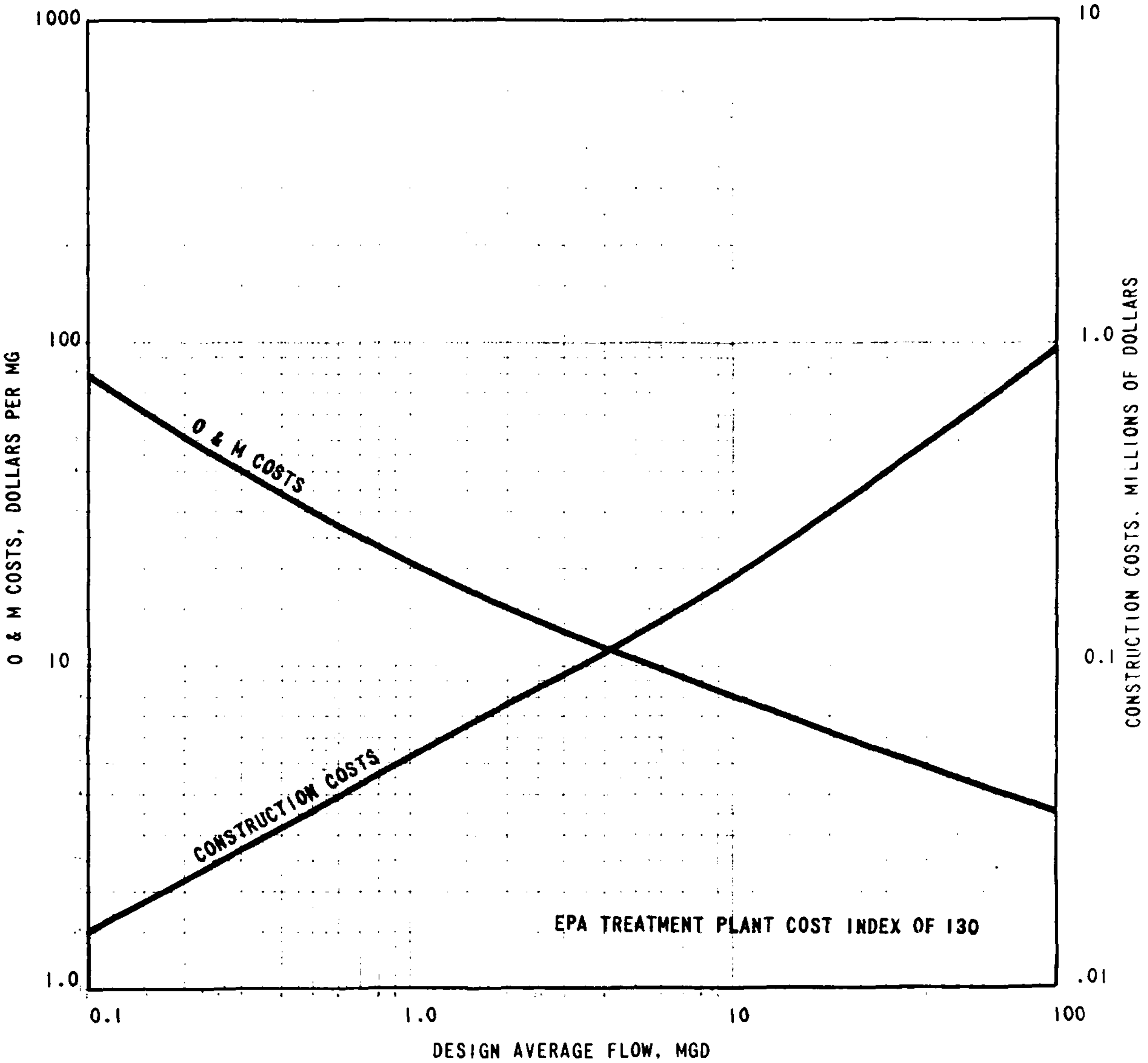
COSTS BASED ON: A. CARBON CONTACT 20 MIN., DOSAGE = 300 LBS/MG

B. CARBON CONTACT 40 MIN., DOSAGE = 1200 LBS/MG

COSTS INCLUDE: CARBON REGENERATION

NOTE: CURVE "A" COST CAN BE USED FOR DECHLORINATION

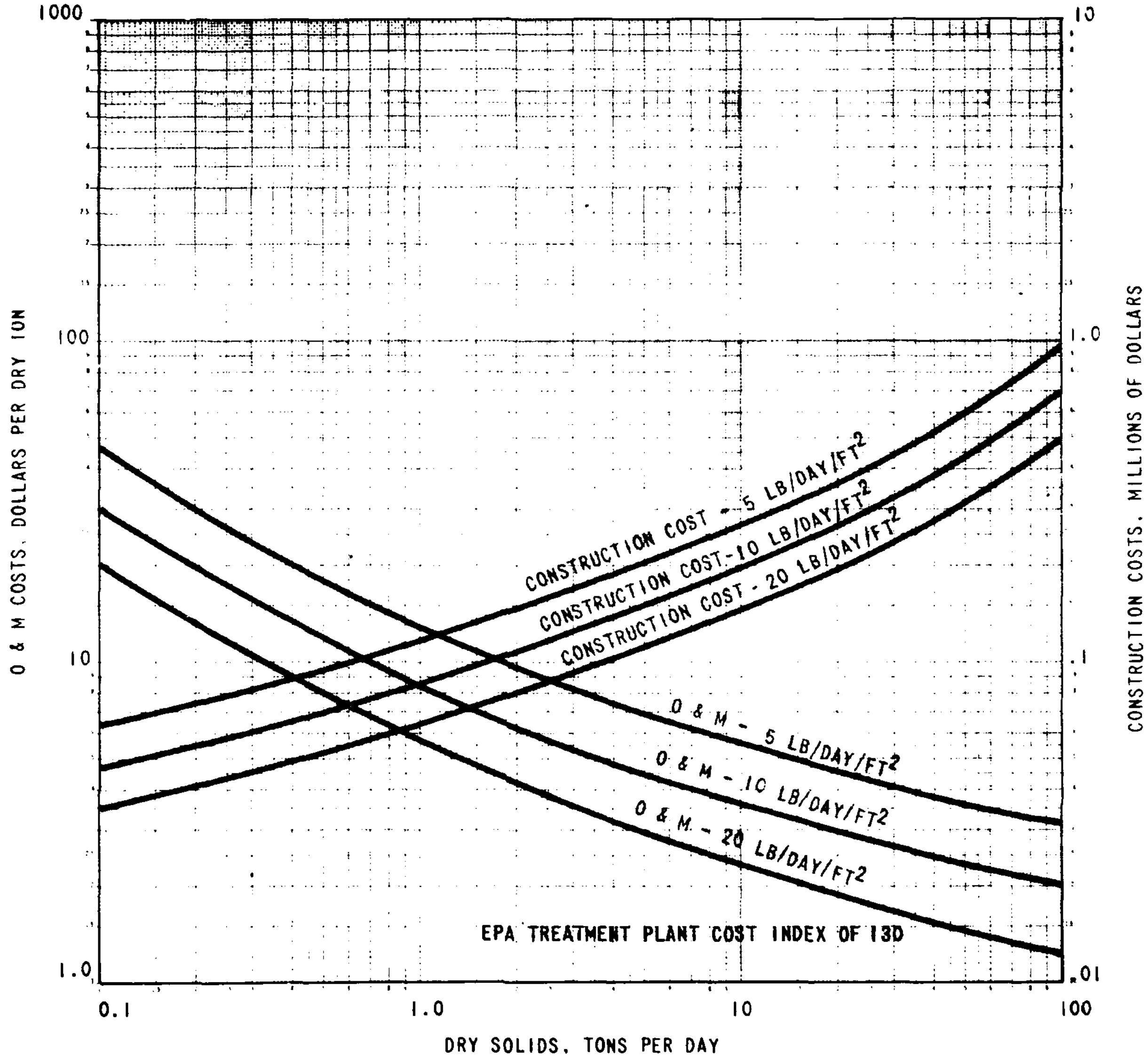
Figure B-18



POST - AERATION

COSTS BASED ON: 1. DETENTION TIME OF 30 MINUTES AT AVERAGE FLOW.
2. AIR SUPPLY OF 100 CFM/MGD FLOW.

Figure B-19



GRAVITY THICKENING

COSTS INCLUDE: THICKENER, CONTROLS, SLUDGE PUMPS.

COSTS BASED ON: LOADING RATE AS SHOWN, TANK DEPTH 10 FT.

NOTES:
1. LOADING RATE OF 5 LB/DAY/FT^2 APPLICABLE TO WASTE ACTIVATED SLUDGE.
2. LOADING RATE OF 10 LB/DAY/FT^2 APPLICABLE TO PRIMARY/WASTE ACTIVATED MIXED.
3. LOADING RATE OF 20 LB/DAY/FT^2 APPLICABLE TO PRIMARY SLUDGE.
4. EXPECTED PERFORMANCE:

LOADING RATE	INITIAL SOLIDS	UNDERFLOW SOLIDS
5 LB/DAY/FT^2	0.8-1.2%	2.5-3.5%
10 LB/DAY/FT^2	2-3%	4-6%
20 LB/DAY/FT^2	3-6%	7-10%

Figure B.20

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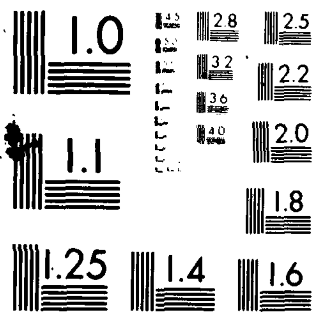
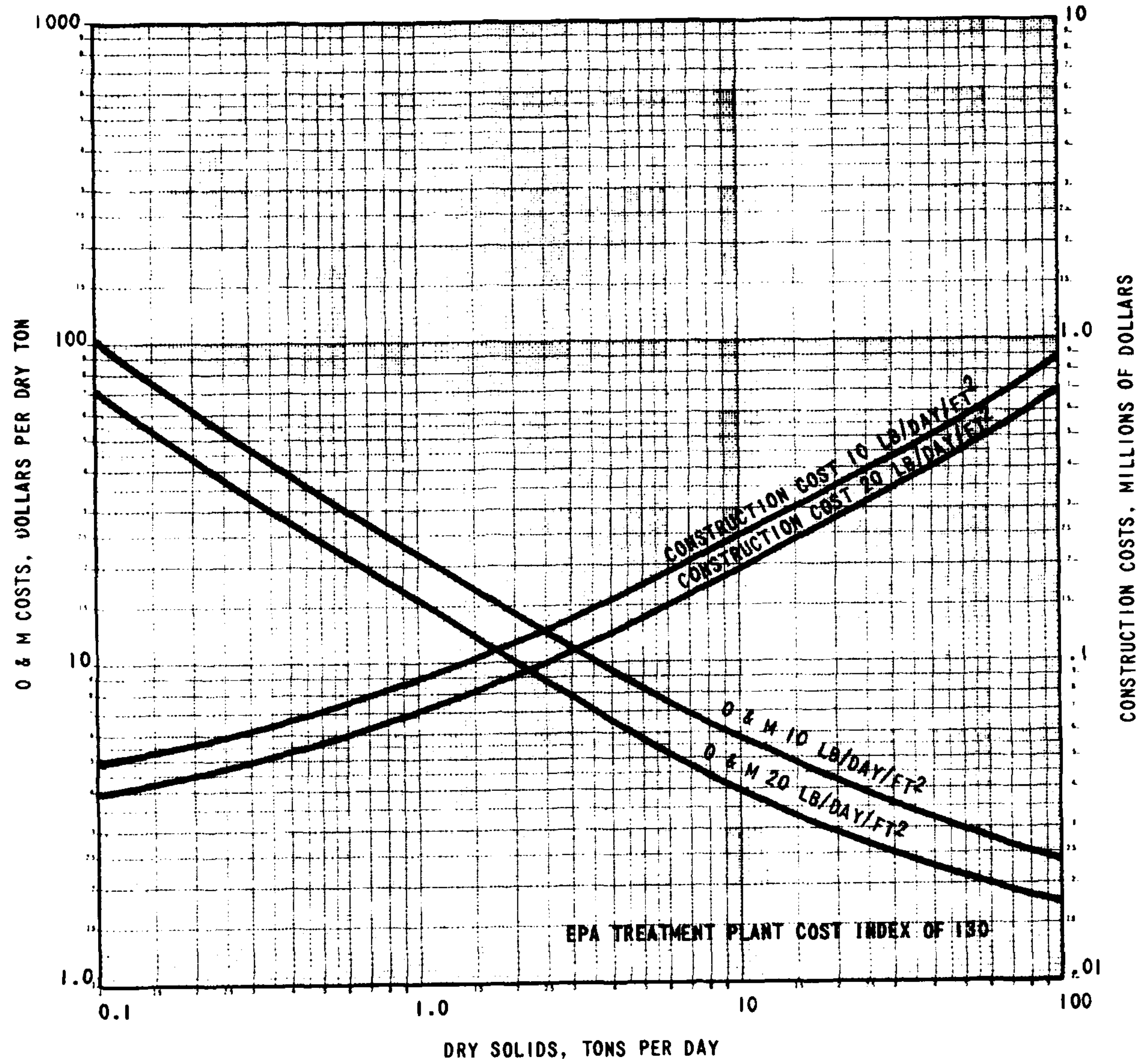


MICROCOPY RESOLUTION TEST CHART

NATIONAL BUREAU OF STANDARDS-1963-A



FLOTATION THICKENING

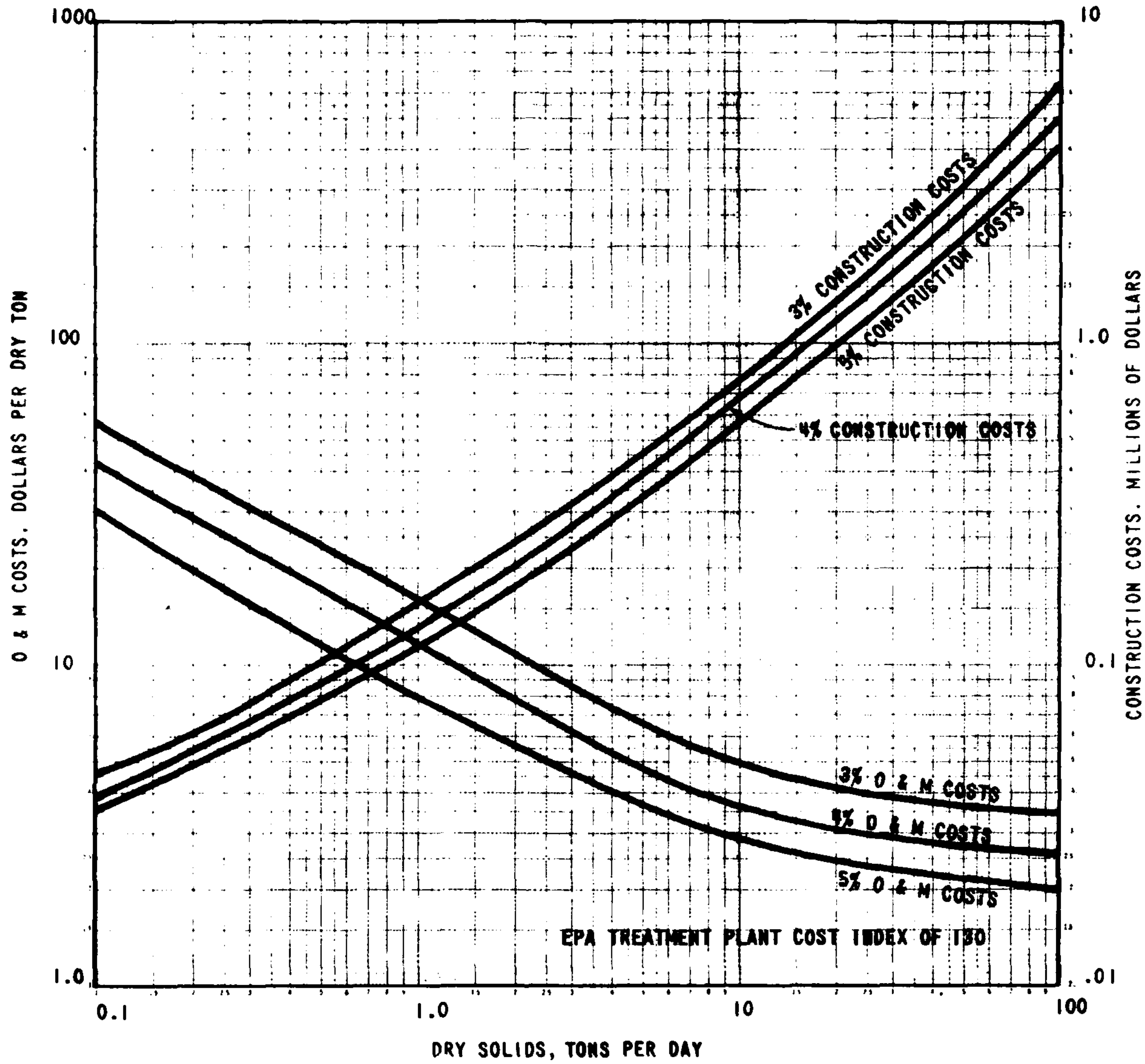
COSTS INCLUDE: THICKENER, CONTROLS, AIR SYSTEM, SLUDGE PUMPS.

COSTS BASED ON: LOADING RATES AS SHOWN, TANK DEPTH 10 FT.

NOTES:
1. LOADING RATE OF 10 LB/DAY/FT^2 APPLICABLE TO WASTE ACTIVATED SLUDGE.
2. LOADING RATE OF 20 LB/DAY/FT^2 APPLICABLE TO PRIMARY/WASTE ACTIVATED MIXED.
3. EXPECTED PERFORMANCE:

LOADING RATE	INITIAL SOLIDS	THICKENED
10 LB/DAY/FT^2	0.8-1.2%	4-6%
20 LB/DAY/FT^2	2-3%	6-8%

Figure B-21



TWO STAGE ANAEROBIC DIGESTION

COSTS INCLUDE: SLUDGE HEATING, CIRCULATING, AND CONTROL EQUIPMENT
TWO DIGESTION TANKS.

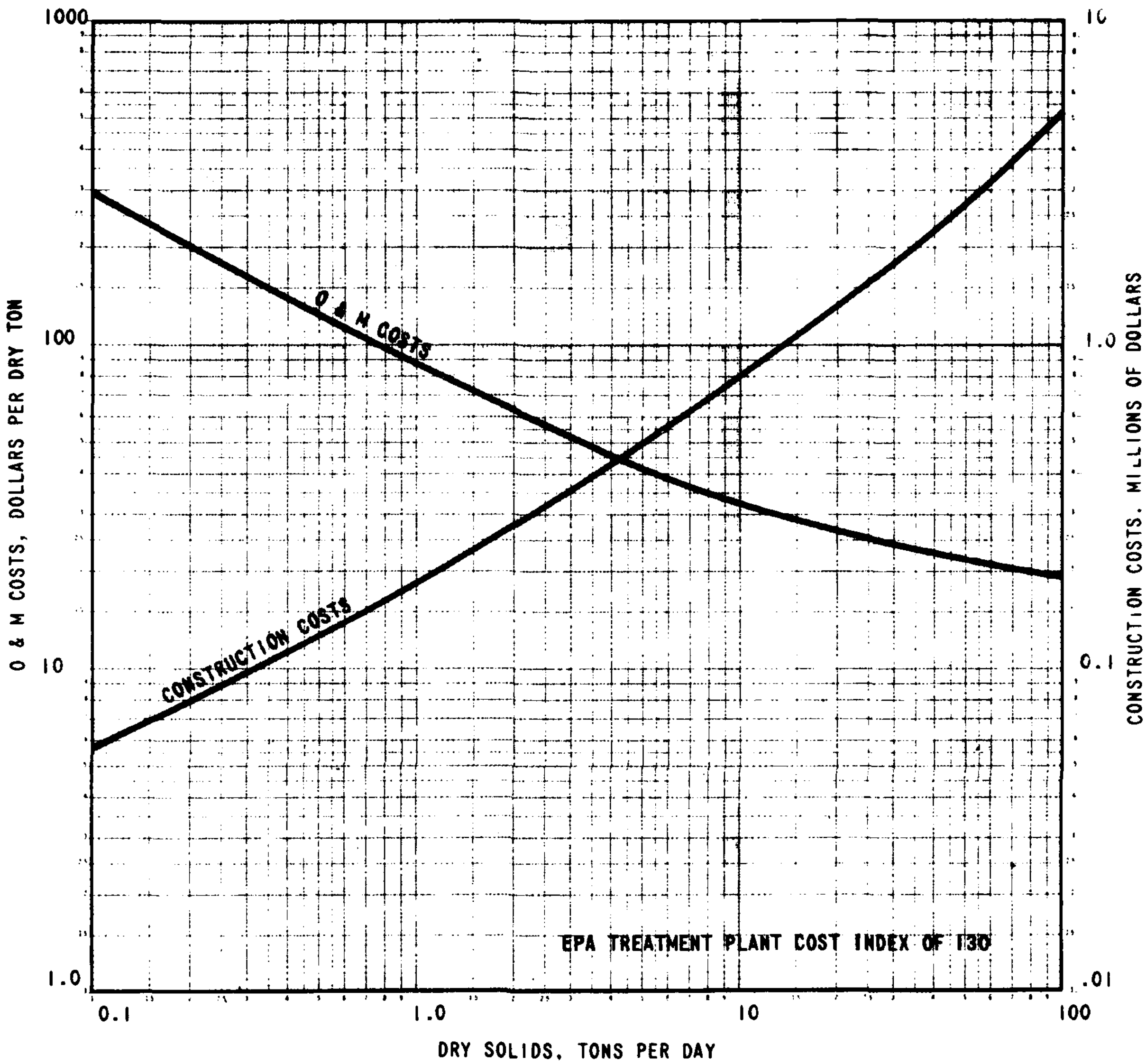
COSTS BASED ON: 1. 25 DAYS OF TOTAL DETENTION TIME IN THE TWO DIGESTER SYSTEM.

2. FEED SOLIDS AS SHOWN.

NOTES: 1. EXPECTED PERFORMANCE 40% DRY SOLIDS REDUCTION.

2. 3 TO 4% SOLIDS EXPECTED FROM DIGESTER.

Figure B-22



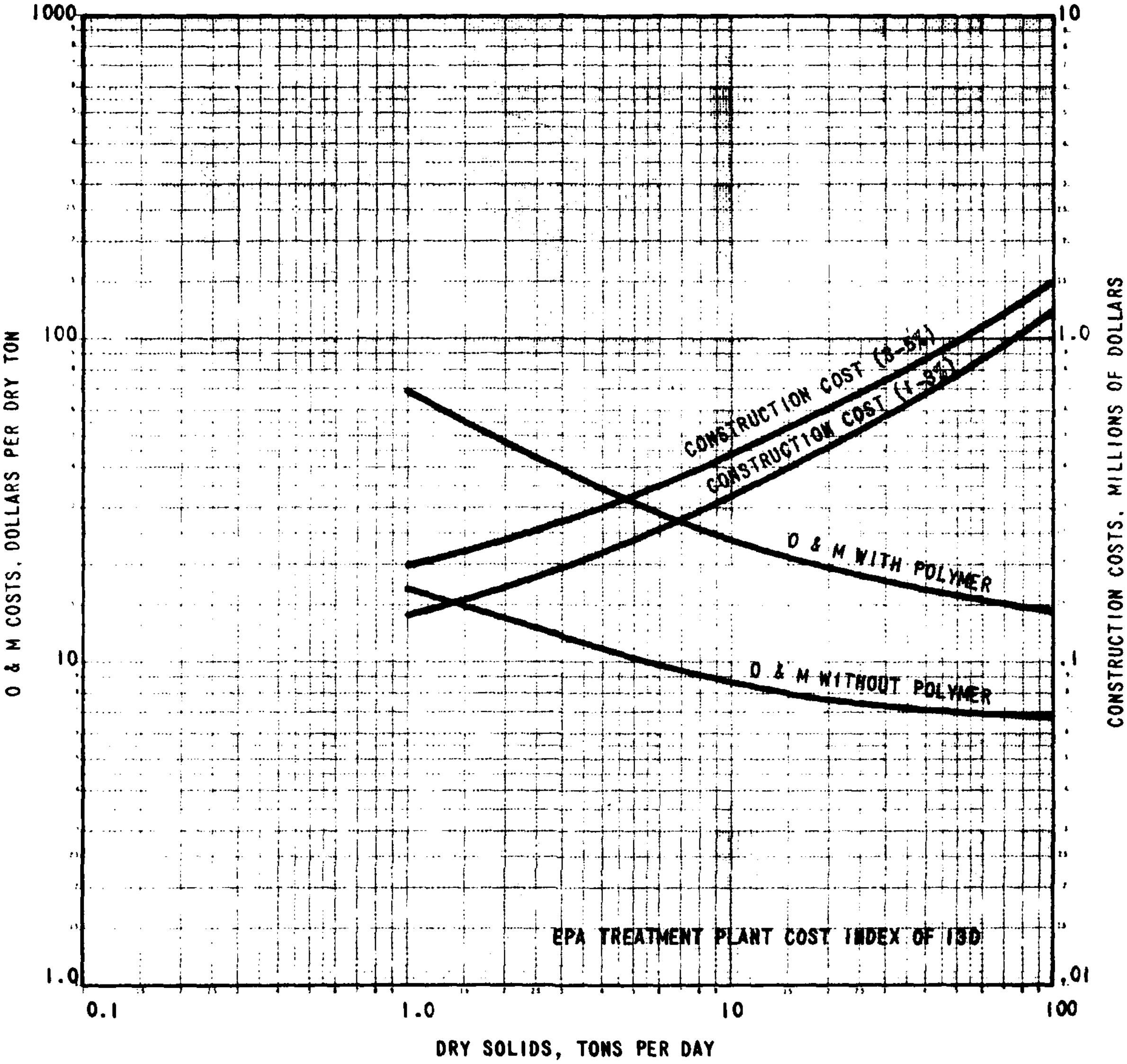
AEROBIC DIGESTION

COSTS BASED ON: 1. DETENTION TIME OF 15 DAYS.
2. 3% INCOMING SOLIDS.
3. AIR SUPPLY OF 30 CFM PER 1000 CU. FT. OF TANK.

COSTS INCLUDE: TANKS AND DIFFUSED AIR SYSTEM.

NOTES: 1. EXPECTED PERFORMANCE 40% DRY SOLIDS REDUCTION.
2. 4 TO 5% SOLIDS EXPECTED FROM DIGESTER.

Figure B-23



DEWATERING, CENTRIFUGES

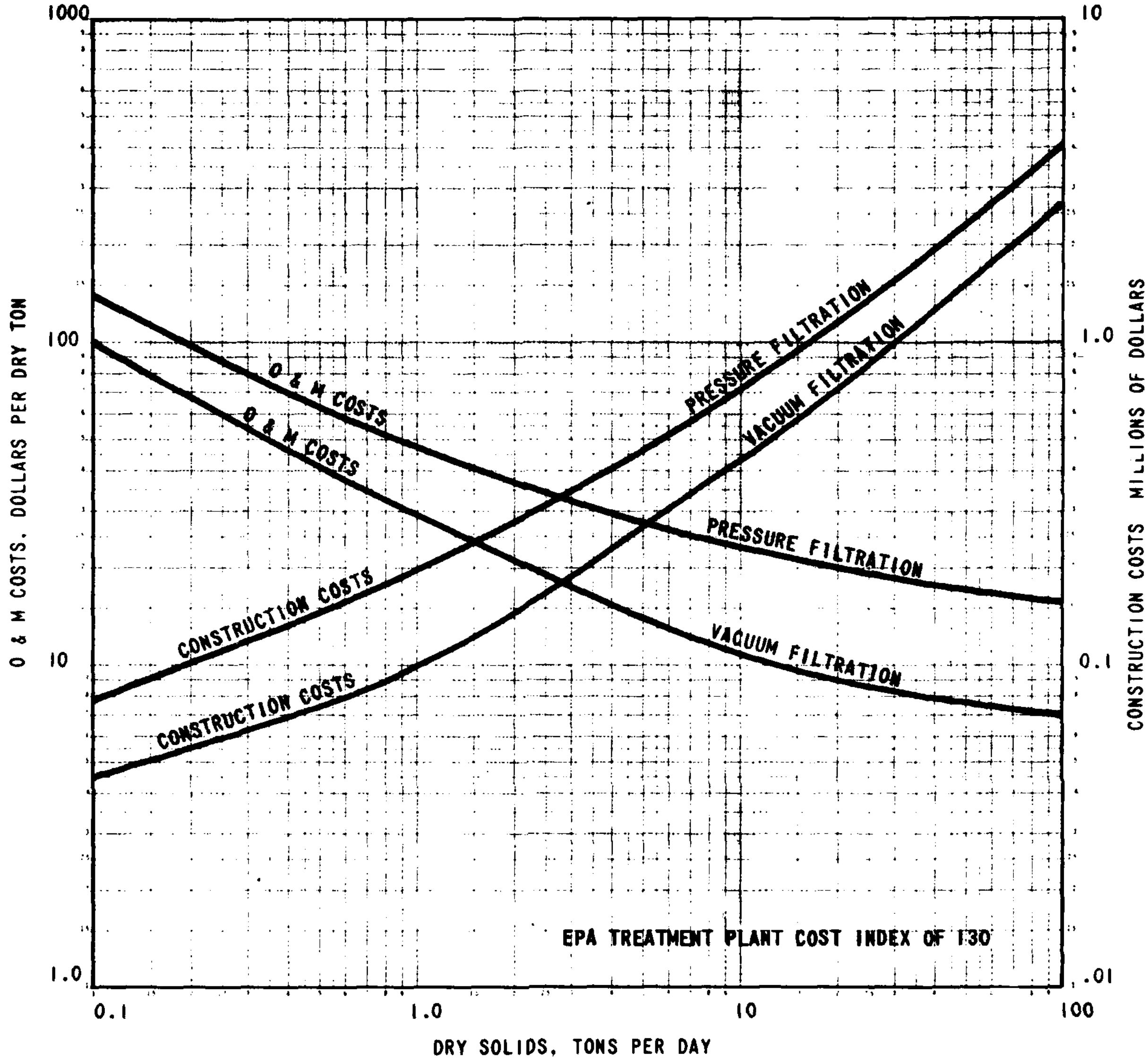
COSTS INCLUDE: CENTRIFUGES, CONTROLS, HOUSING.

COSTS BASED ON: LOADING AS SHOWN, POLYMER 10 LB/TON.

NOTES:
1. 3 $LB/FT^2/HR$ APPLICABLE TO WASTE ACTIVATED.
2. 5 $LB/FT^2/HR$ APPLICABLE TO PRIMARY SLUDGE ± BIOLOGICAL SLUDGE IN DEWATERING APPLICATIONS BEFORE OR AFTER DIGESTION.
3. EXPECTED PERFORMANCE:

SOLIDS IN	SOLID OUT	SOLIDS CAPTURE	CHEMICALS
1-3%	4-8%	80-90%	NO
1-3%	15-20%	85-95%	YES
3-5%	20-25%	50-70%	NO
3-5%	25-30%	90-95%	YES

Figure B-24



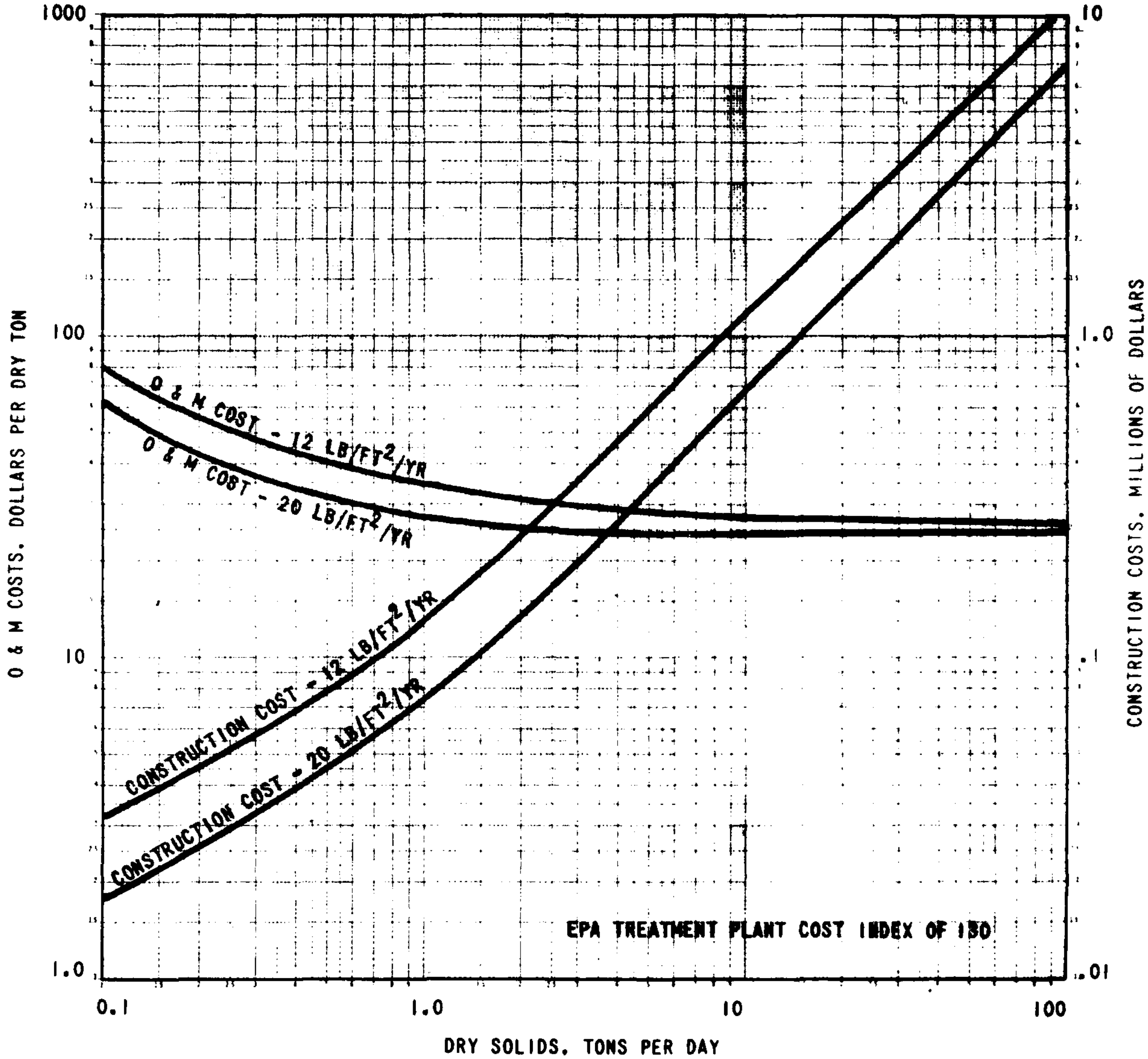
DEWATERING - VACUUM & PRESSURE FILTRATION

COSTS INCLUDE: CHEMICAL CONDITIONING AND FILTER BUILDING.

COSTS BASED ON: VACUUM FILTER YIELD OF 5 LB. DRY SOLIDS PER SQ. FT. PER HOUR. PRESSURE FILTER CYCLE TIME OF 2 HOURS.

NOTES:
1. EXPECTED PERFORMANCE 20-25% SOLIDS CAKE WITH 90-95% SOLIDS CAPTURE WITH 2-4% FEED WITH VACUUM FILTER.
2. EXPECTED PERFORMANCE 35-45% SOLIDS CAKE WITH 95% SOLIDS CAPTURE WITH 2-4% FEED WITH PRESSURE FILTRATION.
3. CONDITIONING CONSISTS OF 3-5% FERRIC CHLORIDE AND 8-10% LIME, BUT ASH (FROM INCINERATION) CAN ALSO BE USED FOR PRESSURE FILTERS WHICH CAN LOWER O & M COSTS SHOWN.

Figure B-25



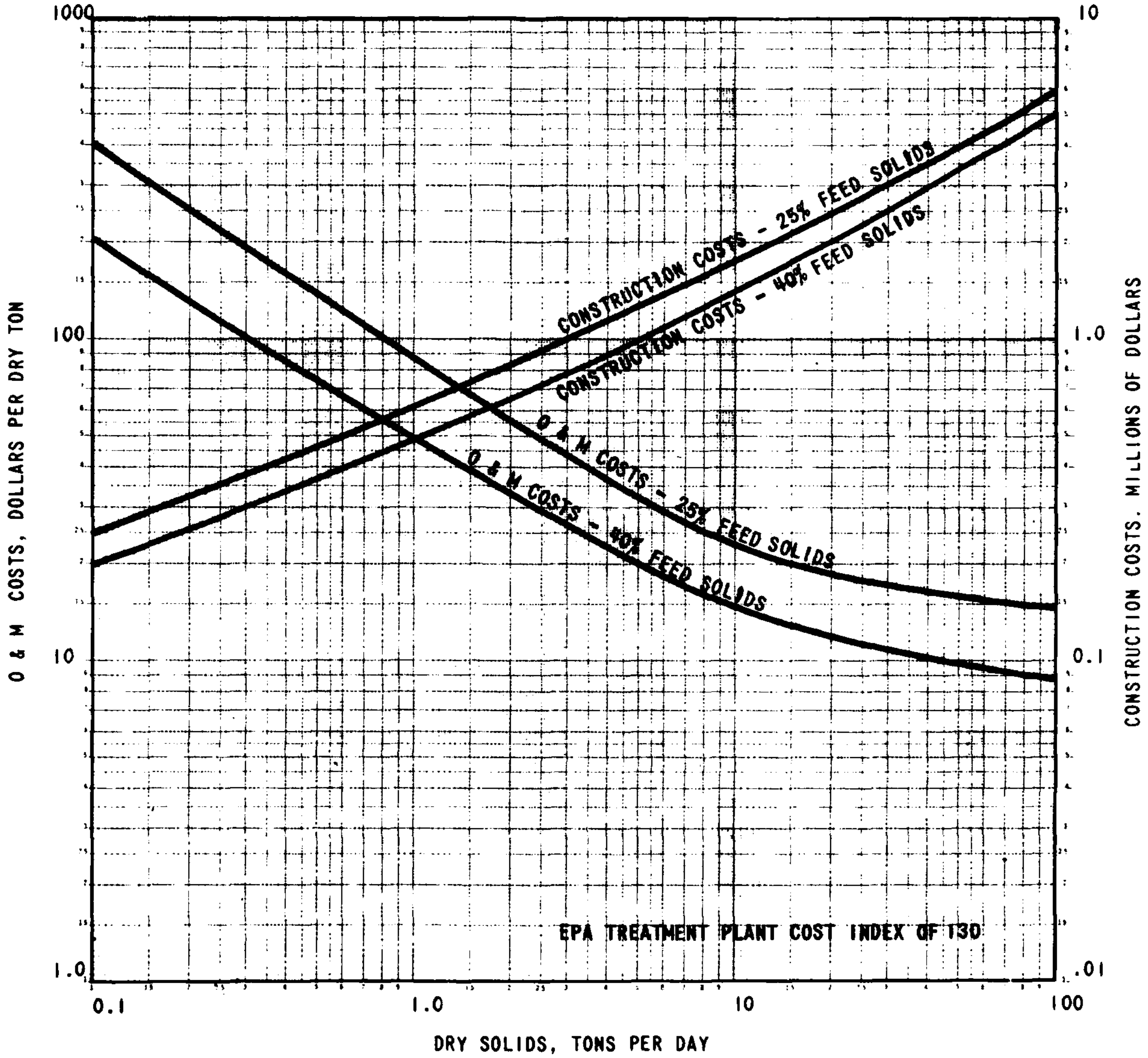
SLUDGE DRYING BEDS

COSTS INCLUDE: SAND & GRAVEL, DISTRIBUTION PIPING, LAND, AND UNDERDRAINS.

COSTS BASED ON: LOADINGS AS SHOWN, 3%-5% SOLIDS TO BEDS.

NOTES:
1. LOADING RATE OF 12 $LB/FT^2/YR$ APPLICABLE TO BIOLOGICAL SLUDGES FROM AEROBIC DIGESTION.
2. LOADING RATE OF 20 $LB/FT^2/YR$ APPLICABLE TO BIOLOGICAL SLUDGES FROM ANAEROBIC DIGESTION.
3. EXPECTED PERFORMANCE: DEWATERS TO 40% SOLIDS.

Figure B-26

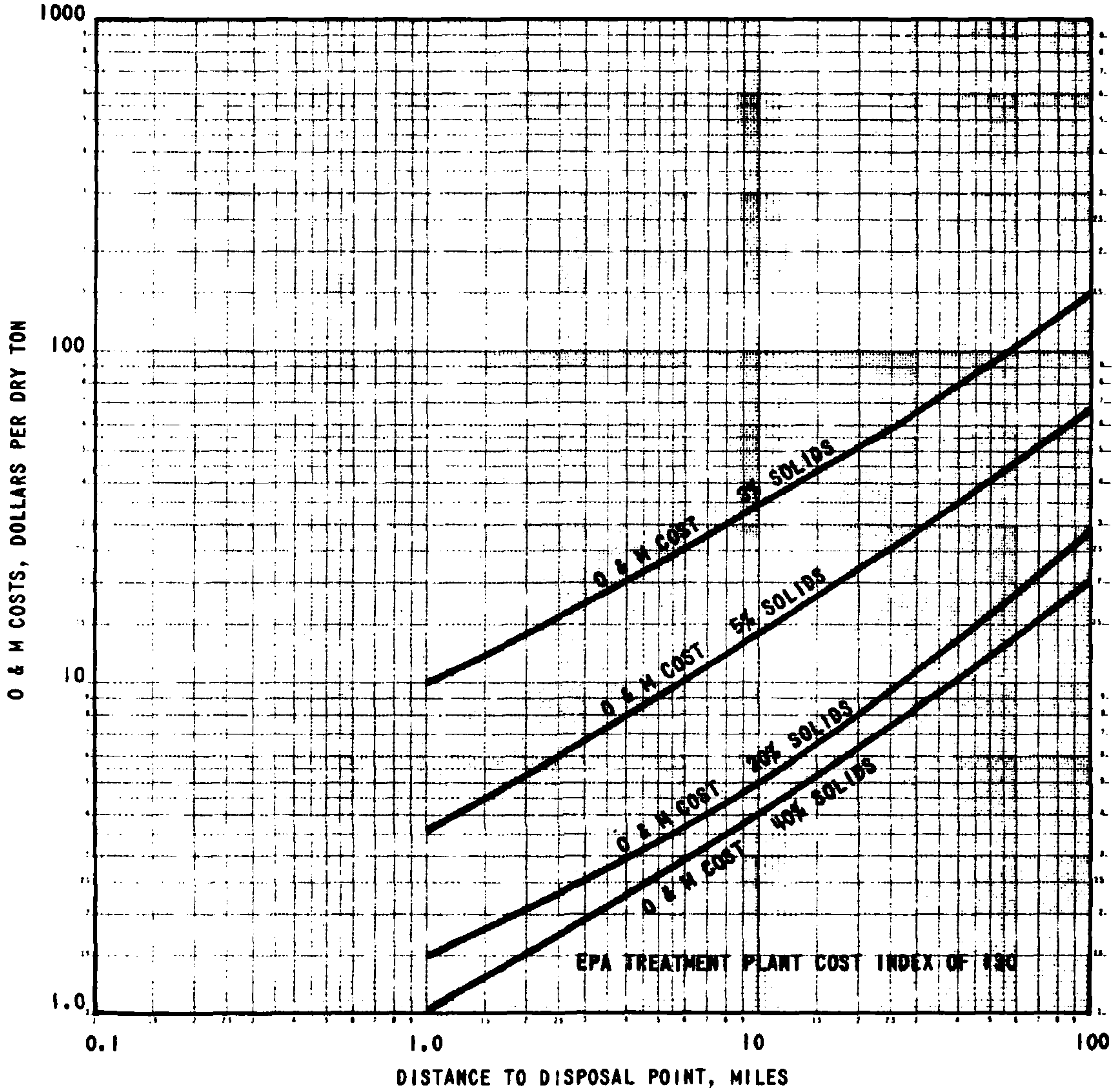


MULTIPLE HEARTH INCINERATION

COSTS BASED ON: FEED SOLIDS AS SHOWN.

NOTE: EXPECTED PERFORMANCE 80% VOLUME AND 75% WEIGHT REDUCTION FOR INCOMING SLUDGE.

Figure B-27

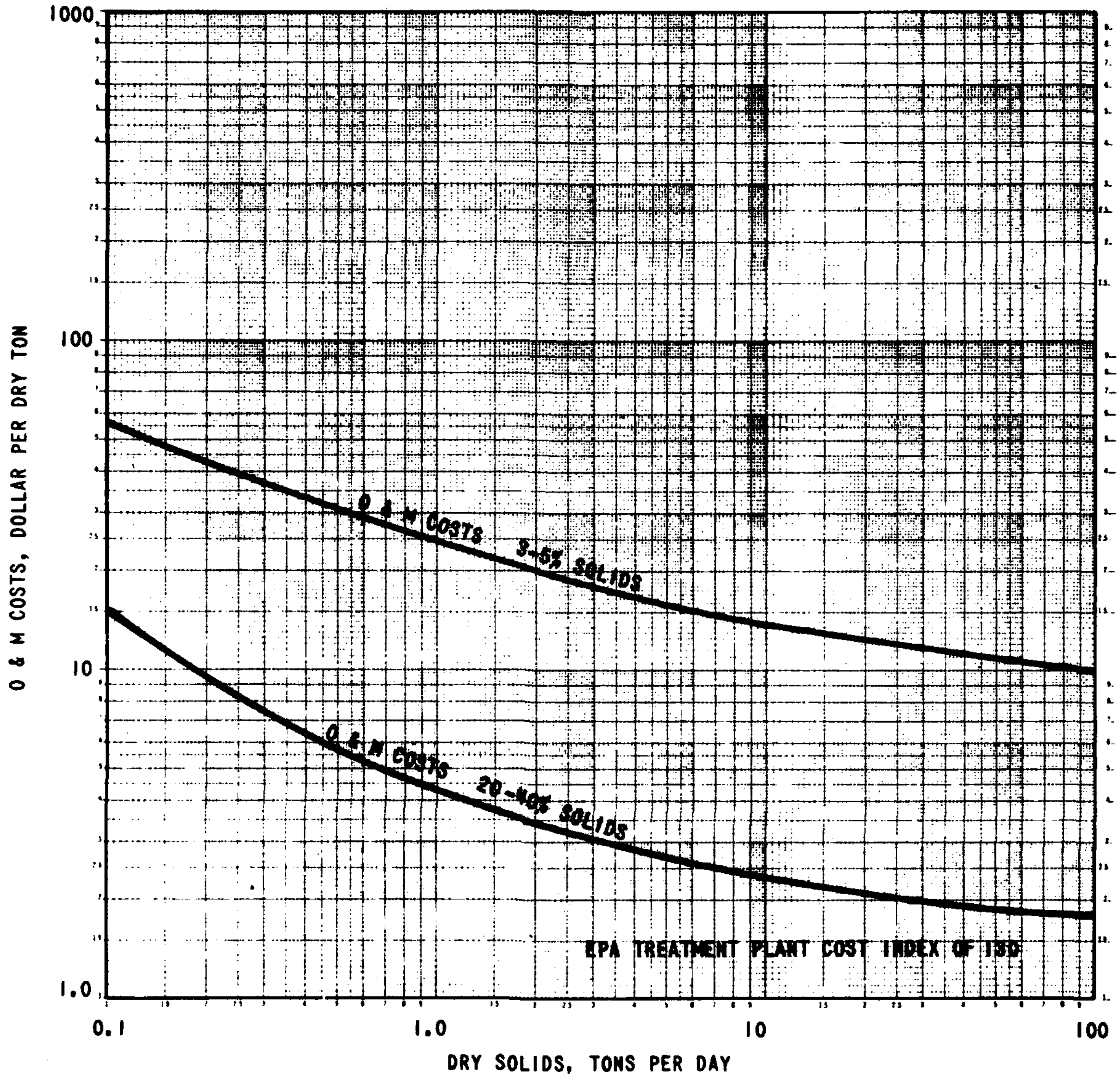


TRUCK HAULING COST

COST BASED ON: TANK TRUCK TRANSPORT FOR 3-5% SOLIDS
DUMP TRUCK TRANSPORT FOR 20-40% SOLIDS
SOLIDS CONTENT AS SHOWN

NOTES:
1. 3% SOLIDS EXPECTED FROM DIGESTED PRIMARY PLUS BIOLOGICAL SOLIDS.
2. 5% SOLIDS EXPECTED FROM DIGESTED PRIMARY.
3. 20% SOLIDS EXPECTED FROM CENTRIFUGE OR VACUUM FILTER DEWATERING.
4. 40% SOLIDS EXPECTED FROM SAND DRYING BEDS OR PRESSURE FILTER DEWATERING.

Figure B-28



LAND SPREADING

NOTES:
1. 3-5% SOLIDS FROM DIGESTED SLUDGE.
2. 20-30% SOLIDS FROM DEWATERED DIGESTED SLUDGE.
3. COSTS EXCLUDE LAND COSTS WHICH MAY REQUIRE ANNUALLY FROM 10 TO 30 ACRES/TON PER DAY FOR ADEQUATE DISPOSAL.
4. COSTS HIGHLY VARIABLE.

Figure B-29

WASTEWATER TRANSMISSION

Costs for gravity and force main sewers are presented in table B-1.

The following assumptions and design criteria were used in developing gravity sewer system costs:

1. Interceptors are constructed of ASTM C 76 reinforced concrete pipe.
2. Pipe sizes were calculated to handle peak flows, using available slopes taken from U.S.G.S. maps. The Manning formula with an "n" coefficient of .013 was used for sizing of lines.
3. The minimum allowable velocity of flow in a sewer is 2.5 feet per second, while the maximum allowable velocity is 10 feet per second.
4. Manholes use standard precast sections of 4-foot diameter for 8-inch to 24-inch lines and 5-foot diameter for 27-inch to 36-inch lines. Sewers 42-inch and larger use horizontal tee sections with 4-foot diameter risers.
5. Manholes are required at each end of an interceptor, every 350 feet for 8-inch to 60-inch sewers, and every 500 feet for sewers over 60-inch diameter.

Force main costs were based on the use of ANSI A21.5 ductile-iron pipe for sizes 6-inch through 24-inch, and the use of AWWA C301 reinforced concrete (steel cylinder type) pressure pipe for 30-inch and larger lines. Sizing of the pipe was based on the peak flow to be carried, maintaining a minimum velocity of 3 feet per second and a maximum velocity of 10 feet per second. Static head was calculated from the U.S.G.S. maps, while friction head was based on the Hazen-Williams formula utilizing a "C" factor of 100. Costs include air vents and associated fittings as required along the force main.

The higher costs for in-city construction reflect added costs of surface restoration (pavement replacement and seeding), clearing and grubbing, and tree removal.

Table B-1 - Wastewater transmission lines installed cost[1]

Gravity Interceptors					Force Mains		
Pipe Size (Inches)	Pipeline[2] (Dollars/Lineal Foot)		Manholes[5] (Dollars/Manhole)		Pipe Size (Inches)	Pipeline[6] (Dollars/Lineal Foot)	
	Rural[3]	In-City[4]	Rural[3]	In-City[4]		Rural[3]	In-City[4]
8	18	36	510	660	6	14	24
10	20	39	510	660	8	17	30
12	21	41	510	660	10	19	33
15	23	44	510	660	12	23	40
18	25	48	510	660	14	26	45
21	28	53	510	660	16	29	50
24	30	56	510	660	18	32	55
27	33	59	590	760	20	36	63
30	38	66	590	760	24	43	75
33	45	75	590	760	30	58	100
36	51	85	590	760	36	73	110
42	67	100	840	1,090	42	90	135
48	75	110	930	1,200	45	105	155
54	85	135	1,040	1,360	54	125	185
60	100	155	1,230	1,600	60	145	200
66	115	160	1,390	1,800	66	170	215

Table B-1 (Continued)

Gravity Interceptors					Force Mains		
Pipe Size (Inches)	Pipeline[2] (Dollars/Lineal Foot)		Manholes[5] (ollars/Manhole)		Pipe Size (Inches)	Pipeline[6] (Dollars/Lineal Foot)	
	Rural[3]	In-City[4]	Rural[3]	In-City[4]		Rural[3]	In-City[4]
72	135	175	1,490	1,930	72	190	240
78	150	195	1,620	2,100	78	220	275
84	175	220	1,790	2,330	84	245	310
90	185	230	1,870	2,430	90	280	350
96	190	240	2,060	2,680	96	295	370
102	215	270	2,250	2,920			
108	260	325	2,380	3,090			
120	280	350	3,400	4,430			
132	335	445	4,000	5,190			
144	425	530	4,740	6,160			

[1]Based on third quarter, 1977 costs.

[2]ASTM C 76 Reinforced concrete pipe.

[3]No rock excavation or extensive dewatering.

[4]Includes dewatering, sheeting, surface restoration.

[5]Precast for sizes 8-inch through 36-inch. Horizontal tees with 4-foot diameter risers for sizes over 36 inches.

[6]ANSI A21.5 ductile iron pipe for 6- to 24-inch; AWWA C301 reinforced concrete (steel cylinder) pressure pipe for 30- to 96-inch.

Source: Stanley Consultants

Costs of wastewater transmission facilities are very site-specific, but the information provided will allow assessment of alternatives at the preliminary planning level. Costs of river crossings are taken as three times the cost shown in table B-1.

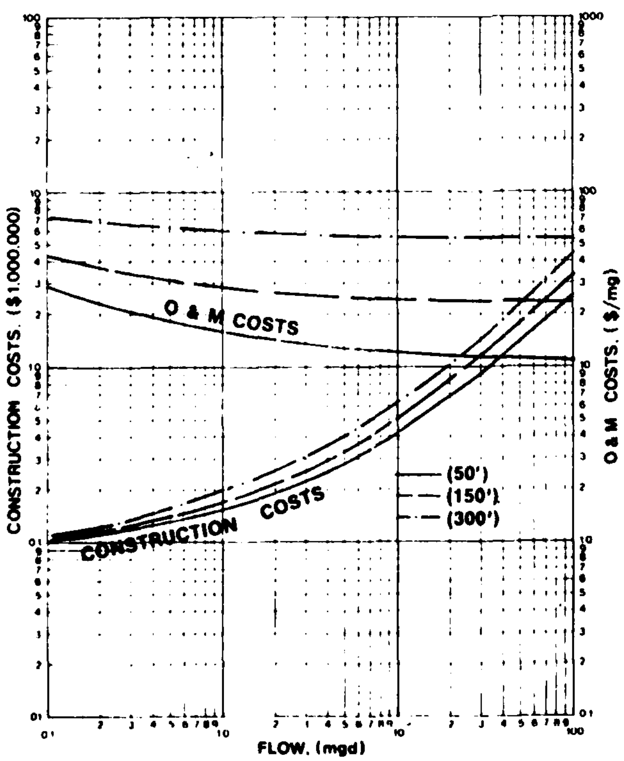
PUMPING STATIONS

DESIGN CRITERIA

Pumping station costs relate primarily to the peak flow to be handled and the total dynamic head (static head plus friction head calculated from the length of force main using the friction factor from the Hazen-Williams formula). As the head increases, larger motors are required for the pump, and construction and operation costs increase.

COSTS

Pumping station cost curves were developed for three ranges of total dynamic head. The construction cost of the pumping station includes a fully enclosed wet well/dry well type structure, pumping equipment with standby facilities, piping and valves within the structure, and necessary controls and electrical work. The costs used for construction and operation and maintenance of pumping stations are shown on figure B-30 below.



TRANSMISSION PUMPING
COSTS BASED ON:
PUMPING HEADS AS SHOWN
COSTS INCLUDE:
WET WELL, DRY WELL, ENCLOSING STRUCTURE, PIPING, VALVES, AND CONTROLS
NOTE: 1. CONSTRUCTION COSTS RELATED TO PEAK FLOW
2. OPERATION AND MAINTENANCE COSTS RELATED TO AVERAGE FLOW

FIGURE B-30

SUMMARY AND RECOMMENDATIONS

This report presents the results of the stage 3 wastewater study of the combined sewer system of Grand Forks, North Dakota. The study is part of the overall Grand Forks-East Grand Forks Urban Water Resources Study. A summary of the stage 3 investigations and conclusions follows:

1. The study area includes approximately 850 acres of Grand Forks that are presently served by a combined sewer system. The combined sewer system collects both sanitary waste and stormwater drainage and conveys the wastewater to pump stations. The study area is fully developed and predominantly residential.
2. Under normal conditions, wastewater consisting predominantly of domestic wastes is collected by the combined sewer system. The wastes are pumped through a main interceptor which carries the sewage to the wastewater treatment lagoons. During appreciable rainfall events, pump station capacities are exceeded, and combined sewer overflows are discharged directly to the Red River of the North.
3. The water supply for Grand Forks and other local communities is the Red River of the North. Combined sewer overflows introduce large quantities of pollutants to the river during overflow periods. These pollutants, including solids, organics, nutrients, bacteria, and floatables, have an adverse impact on

the water quality of the river and thus the water supply and other beneficial uses in the area.

4. The inadequate capacity of the combined sewer system during appreciable rainfall events results in localized street flooding and basement backups. The presence of sanitary waste in the surface and basement flooding constitutes an undesirable health impact.

5. The National Pollutant Discharge Elimination System (NPDES) permit issued to the city of Grand Forks specifies a schedule for elimination or significant reduction of the combined sewer discharges. As a condition of the permit, the city is required to submit a report to the State of North Dakota and the U.S. Environmental Protection Agency (EPA) detailing an engineering evaluation of the problem and possible alternatives. The report is to develop the most cost-effective and environmentally sound method for meeting the conditions of the NPDES permit. This report, completed as part of the Urban Water Resources Study, serves that purpose.

6. During the conceptual development stage, many alternatives were evaluated for possible use at Grand Forks. After preliminary screening, plans including combined sewer separation, treatment in each service area, regionalized detention and treatment, and source or collection system management were selected for detailed evaluation. The analysis included sizing and locating facilities, estimating costs, and assessing environmental impacts. The alternatives were ranked on the basis of monetary costs, environmental effects, contribution to goals, feasibility, reliability, implementability, public acceptability, and resource requirements.

7. The recommended plan for Grand Forks is to provide separated sewers in the existing combined sewer area complemented by an effective street sweeping program. The study developed alternatives for each of four service areas. Each service area has a distinct separation plan recommended as detailed in this report. Flow measurements should be made following sewer separation to determine if the existing pump stations have adequate peaking capacity for the new flow conditions. The estimated project cost for the total study area is $14,521,000 based on May 1979 prices. The separated system is estimated to cost $23,750 per year to operate and maintain. Implementation steps are outlined in this report.

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SUMMARY OF WASTEWATER INVESTIGATIONS

In 1975, the U.S. Army Corps of Engineers launched a comprehensive study of water resources in the Grand Forks-East Grand Forks area. The 6-year planning effort, the Grand Forks-East Grand Forks Urban Water Resources Study, sought solutions to problems in flood control, water supply, and wastewater management. Wastewater management, the subject of this report, has progressed through several stages:

- Stage 1 identified the needs and problems of the urban area.
- Stage 2 developed alternatives to meet these needs.
- Stage 3 evaluated possible solutions to the combined sewer overflow problem and developed a cost-effective plan.

The stage 2 wastewater report, entitled Wastewater Study - Problem Identification/Alternative Formulation/Evaluation was completed by Stanley Consultants in August 1978; this report was subsequently distributed as the Stage 2 Wastewater Appendix in September 1978. It identified water quality problems and needs of the urban study area and formulated alternative solutions to those problems and needs. The stage 2 study specifically investigated treatment facilities and urban runoff in relation to water quality.

TREATMENT FACILITIES

All communities in the study area rely on lagoons for wastewater treatment. The capacity of the East Grand Forks facility appears adequate to meet the projected demands until about 1995.

Grand Forks currently has a facility expansion project that will adequately serve the city until about 1995. Some of the facilities of small area communities do not satisfy present population levels, but the communities are working toward meeting standards. Several alternatives were developed for the study area to meet the treatment needs through the 50-year planning period ending in 2030. The alternatives included:

- Regionalization of systems to handle most communities and major industries.
- Maximum use of existing facilities.
- Combinations of some facilities (partial regionalization).

Alternative types of facilities were examined to meet various degrees of treatment to be decided by future legislation and/or regulations. Possible wastewater system improvements range from merely increasing the capacity of the existing plant in order to maintain the present degree of effluent control to using advanced mechanical treatment processes or land application of lagoon effluent to achieve zero discharge of critical pollutants.

The stage 2 evaluation found the most cost-effective alternative was separate lagoon systems. The study recommended that point source wastewater treatment not be investigated further because the communities' plans for future wastewater treatment already are based on the most cost-effective alternative--lagoon systems.

URBAN RUNOFF

Urban runoff refers to two types of runoff: nonpoint sources, such as overland flow runoff, and intermittent point sources, such as combined sewer overflows or storm sewer discharges. The stage 2 study identified combined sewer overflows from Grand Forks (which has the only combined sewers in the area)

as the most significant wastewater-related problem in the study area. The report recommended that combined sewer problems in Grand Forks be investigated in detail in stage 3 of the urban study. This investigation should include a recommended facilities plan, a detailed economic evaluation, and nonstructural alternatives, such as street sweeping and sewer flushing.

The following report presents the investigations and findings of the stage 3 wastewater study.

INTRODUCTION

GENERAL

The St. Paul District, Corps of Engineers, is conducting the Grand Forks-East Grand Forks Urban Water Resources Study. The overall study is a cooperative effort between local, State, and Federal agencies to develop plans for solving water resource and related land resource problems in the Grand Forks-East Grand Forks urban area. The water resource problems under investigation include water supply, flood control, urban drainage, and wastewater management. The overall study is scheduled for completion in 1981.

This report is the stage 3 wastewater study of the Grand Forks combined sewer area. Wastewater related problems were investigated in previous portions of the urban study. The stage 2 wastewater report summarizes water quality problems in the urban area and evaluates alternative solutions. That report concludes that expansion of the present lagoon systems represents the most cost-effective approach to point source wastewater management. The stage 2 work also identified combined sewer overflows in Grand Forks as a significant public health problem. The purpose of this stage 3 study has been to investigate the wastewater problems related to combined sewer overflows and to evaluate in detail a wide range of possible solutions, leading to development of the most cost-effective plan.

DESCRIPTION OF STUDY AREA

For purposes of this stage 3 investigation, the study area includes the portion of Grand Forks that is presently served by

combined sewers. The combined sewer area has been subdivided into six subareas as shown on figure 1. Area 4 has already been separated, and sewer separation is currently under way in Area 3. These two areas have therefore been excluded from this study. Areas 1, 2, 5, and 6 encompass a total of approximately 850 acres. The remainder of Grand Forks is served by separate storm and sanitary sewers and is excluded from this study. Some of the alternatives considered do, however, involve construction of facilities outside of the study area (e.g., detention basins, interceptors).

The combined sewers collect sanitary wastes and stormwater from the tributary area and convey the flow to lift stations at several locations along the Red River of the North. The stations pump the combined flow to the treatment lagoons. During periods of significant rainfall, the combined sewage overflows at the lift stations and is discharged to the river. Suspended solids, biochemical oxygen demand (BOD), floatables, and coliform bacteria are discharged during these overflow events. The existing system and control structures will be discussed in a later section.

The river flow in the vicinity of Grand Forks is controlled by a low head dam, which creates a pool for drinking water supply. Turbidity, coliform, and other chemical parameters in the pool area exceed safe drinking water supply levels and cause negative impacts on fisheries and recreation. The precise degree to which combined sewer overflows pollute the river has not been quantified because of a lack of data, but the overflows are thought to have a significant impact. During periods of high river stage, backups of combined sewers flood basements with polluted water. Further discussion of water quality problems is included in the stage 2 report and later in this report.

In recognition of these problems, the city of Grand Forks initiated a phased program for construction of separate sewer

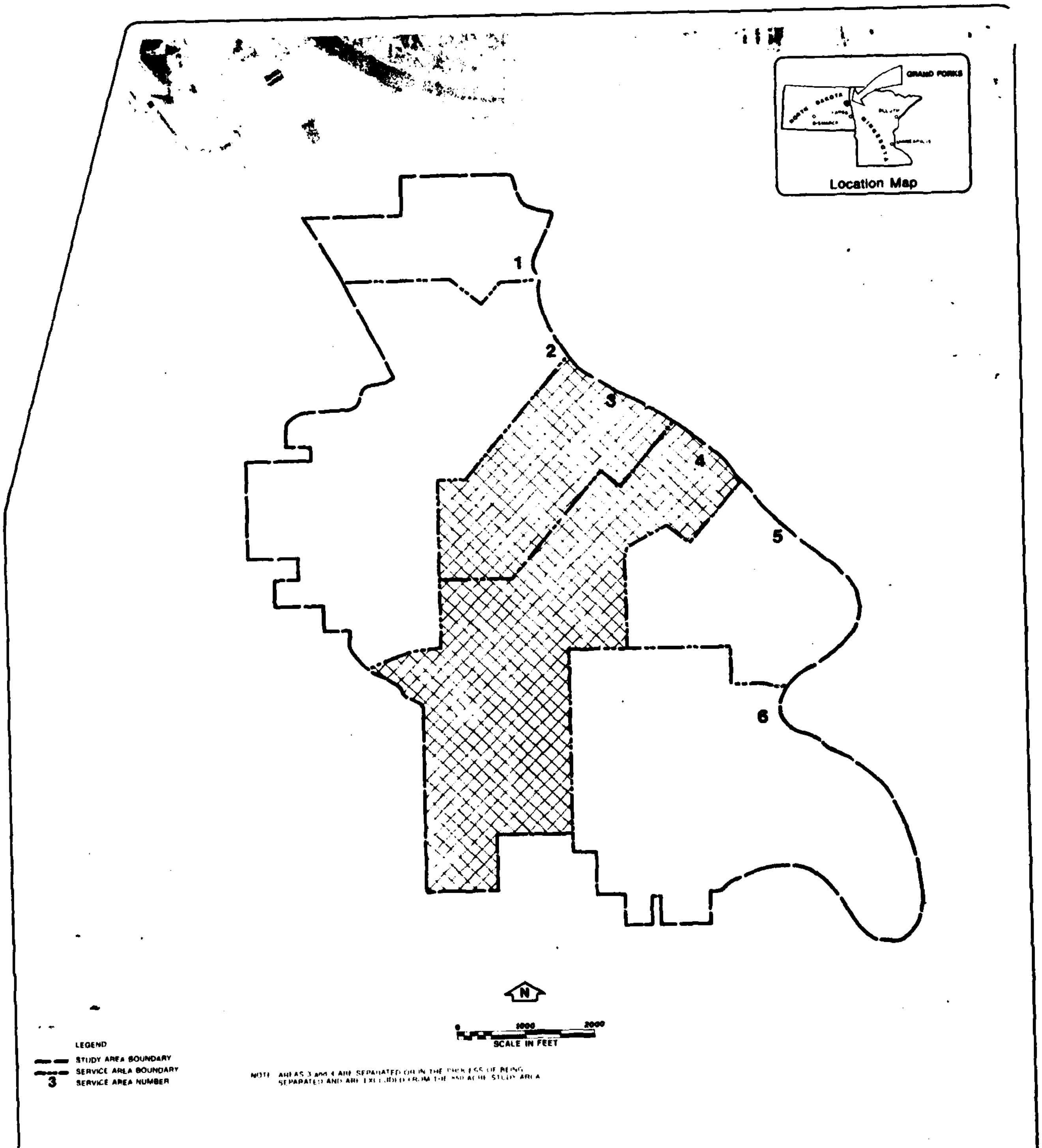

Figure 1 - Study Area

systems in the study area. The first phase of the program was divided into several construction contracts. With the exception of an area in the vicinity of Central Park, the first phase is either completed or currently under construction. A summary of the phased separation program as initiated by Grand Forks is shown on figure 2. This stage 3 study investigates a range of alternatives for the areas included in the city phases II, III, IV, and the portion of phase I which is not under construction.

SCOPE OF INVESTIGATION

The overall objective of this stage 3 work is to determine the most cost-effective means of solving the combined sewer overflow problem. The emphasis in the study is on development of reliable cost information for the various alternative strategies to enable an informed decision to be made. The specific scope of this report includes:

1. Review of existing information to identify:
   - the existing combined sewer system and control structures.
   - land use in the study area.
   - service area to each overflow outfall.
   - population in each service area.
   - other characteristics of the study area.
2. Develop meteorological/hydrological data for use in quantifying combined sewer overflow events.
3. Estimate to the extent possible quantities of pollutants washed into the Red River of the North via the combined sewers.
4. Summarize, on the basis of previous studies, the infiltration/inflow in the Grand Forks combined sewer area.
5. Briefly discuss the water quality of the Red River of the North with regard to beneficial uses.

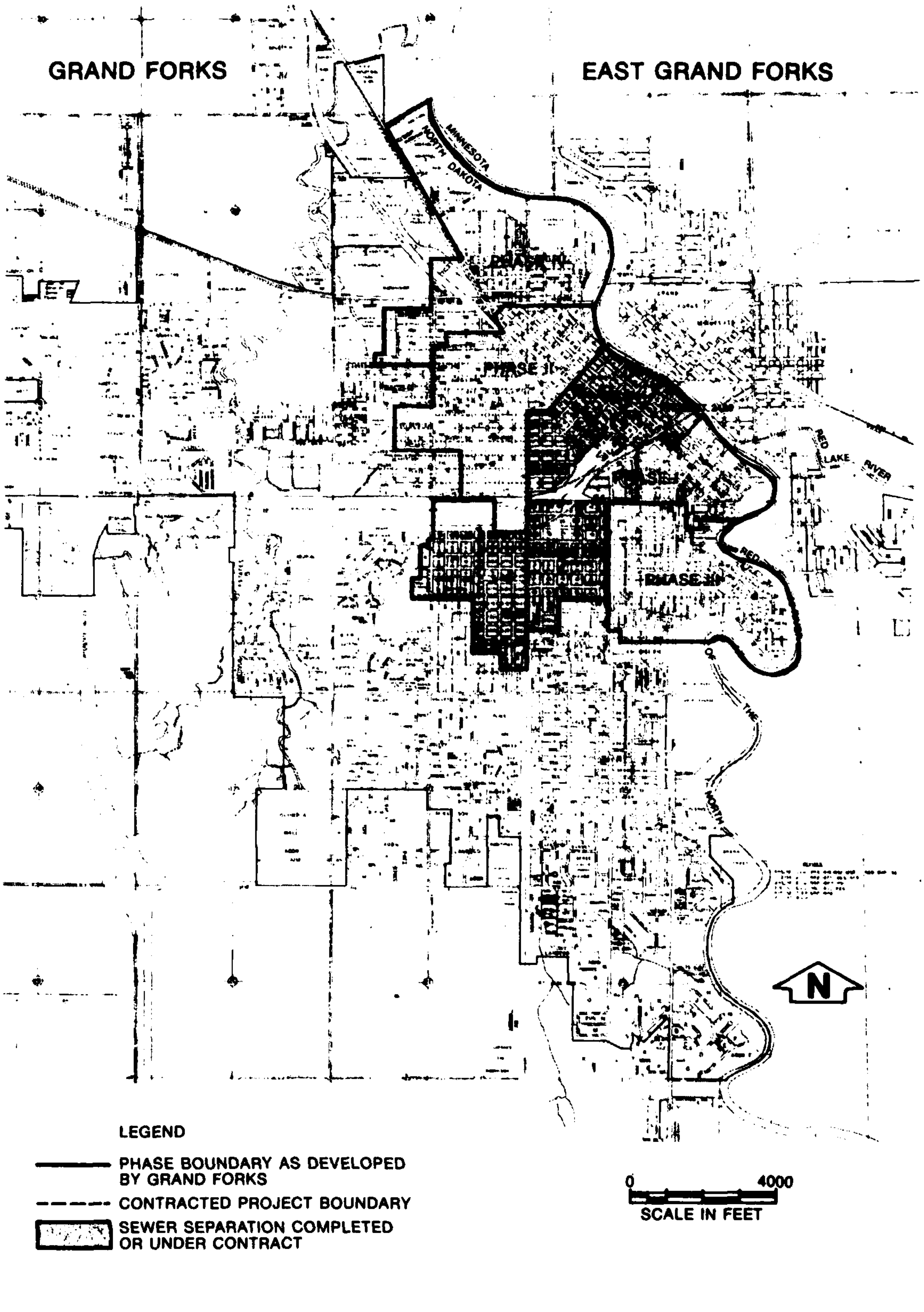

Figure 2 - Current Sewer Separation Work

6. Formulate a range of alternatives for alleviating the problems related to combined sewer overflows, to include:
   - sewer separation.
   - stormwater detention and treatment.
   - swirl concentrators.
   - relocation of water supply intake.
   - collection system management improvements.
   - source management.
7. Develop preliminary alternative layouts at a level of detail adequate for reliable cost estimates.
8. Evaluate alternatives for each service area with regard to:
   - economics.
   - pollutant removal efficiency (cost per pound removed).
   - environmental and social impacts.
   - institutional arrangements.
9. Develop and describe the most cost-effective alternative for each service area.

EFFLUENT LIMITATIONS

In 1972, the Federal Water Pollution Control Act (Public Law 92-500) was passed by the Congress of the United States. This law established the National Pollutant Discharge Elimination System (NPDES). Under NPDES, discharge permits are issued to all wastewater dischargers specifying the volume and characteristics of the wastewater which can be discharged.

In the case of Grand Forks, discharge permit No. ND-0022888 has been issued for all Grand Forks discharges to the river. The combined sewer overflows are designated as Outfalls 001, 002, 003, 004, 005, 011, and 012 in the permit. Page 6 of the permit states:

> Discharges from the above named discharge points are prohibited except where unavoidable to prevent loss of life or severe property damage.

Page 7 specifies that:

> No later than October 1, 1979, the permittee shall provide the North Dakota State Department of Health with an acceptable report containing the results of a detailed engineering evaluation to determine the most cost-effective method of minimizing or eliminating the combined sewer overflows from outfalls 001, 002, 003, 004, 005, 011, and 012. This study shall include a description of and cost estimates for the various available abatement operations together with the anticipated reductions expected in the discharge concentration and discharge amounts of fecal coliforms, BOD, and suspended and floatable solids.

This stage 3 wastewater report serves as a basis for selection of a specific implementation plan. After review of the report, the North Dakota State Department of Health and

U.S. Environmental Protection Agency shall determine the most cost-effective approach to minimize or eliminate the discharges.

Within 60 days of notification of the most cost-effective means, the city of Grand Forks must select a means of controlling the overflows which shall provide, at a minimum, the abatement provided by the most cost-effective procedure. A compliance schedule shall also be submitted to the North Dakota State Department of Health and the U.S. Environmental Protection Agency including, at a minimum, dates to accomplish the following:

1. Submission of an acceptable Step II application for combined sewer controls.
2. Completion of preliminary plans.
3. Completion of final plans.
4. Submission of an acceptable Step III application for combined sewer control.
5. Award of contracts.
6. Commencement of construction.
7. Completion of major construction phases.
8. Completion of all construction.
9. Attainment of operational level.

Upon approval of the compliance schedule by the permit issuing authority, the compliance schedule shall become conditions of the permit.

The deadline for submitting this facilities planning report to the North Dakota State Department of Health and the U.S. Environmental Protection Agency was 1 October 1979. When it became apparent that the report could not be finished by the October deadline, Grand Forks requested a 90-day extension until 1 January 1980. A review copy of the report was submitted to the North Dakota State Department of Health and the U.S. Environmental Protection Agency during November 1979.

STUDY AREA SETTING

ENVIRONMENTAL SETTING

General

This section presents a description of the existing environmental conditions in the study area. The alternatives considered for this project will result in changes in water quality and each involves significant construction activities. At the same time, construction activities are affected by the environmental conditions. Therefore, the environmental setting addresses water resources and those elements of the environment that are likely to affect and be affected by construction.

Physical Elements

The weather of the Grand Forks area is characterized by wide temperature variations and light to moderate rainfall. The mean temperature is $57^{\circ}F$ for April through October and $15^{\circ}F$ for November through March, with a yearly mean of $39^{\circ}F$. The coldest month on record was February 1936, which had an average temperature of $-13^{\circ}F$. The lowest temperature on record is $-44^{\circ}F$ and the highest is $109^{\circ}F$.

The mean annual precipitation at Grand Forks is approximately 20 inches. Average precipitation is 7.50 inches during the spring and 7.88 inches during the summer. Average frost penetration at Grand Forks is 4.5 feet, with an extreme of 7 feet.

Very little topographic relief exists in the study area. The average surface slope is approximately 0.2 percent, with steeper relief along the river. The subsurface formations of the study area consist primarily of igneous and metamorphic

rocks. The surface elevation of this bedrock is approximately 500 feet. The soils are derived almost entirely from glacial till and sediment from glacial Lake Agassiz.(1)

Land Use and Demography

The study area encompasses approximately 850 acres in central Grand Forks. Population density for service areas ranges from 10 to 15 persons per acre, with an average of 13.3 persons per acre. The total study area population is approximately 11,280 persons. The study area is predominantly residential, as shown on figure 3, the land use map.

Groundwater Resources

The study area soils are a silty clay. The bedrock aquifers in the area are characterized by total dissolved solids exceeding 13,000 mg/l and hardness exceeding 3,000 mg/l. Total dissolved solids and hardness decrease as depth decreases.(2)

Several glacial drift aquifers exist in the area. The glacial drift aquifers in the immediate vicinity of the urban area and several artesian wells in Grand Forks County are characterized by small to moderate yields and total dissolved-solids levels exceeding 1,000 mg/l. At low streamflows when groundwater inflow is the major source of surface water runoff, streams is the area exhibit characteristics similar to those of the groundwater.

The low permeability of the Lake Agassiz soils has led to the construction of many artificial drainage channels. The slow drainage also impedes the use of septic tank and tile drain wastewater treatment systems for individual homes and commercial establishments.(1)

Surface Water Hydrology

The major surface water resources of the study area are the Red River of the North and the Red Lake River. The flow of water in these and other surface water resources of the study area is influenced by reservoir operation and climatic factors.

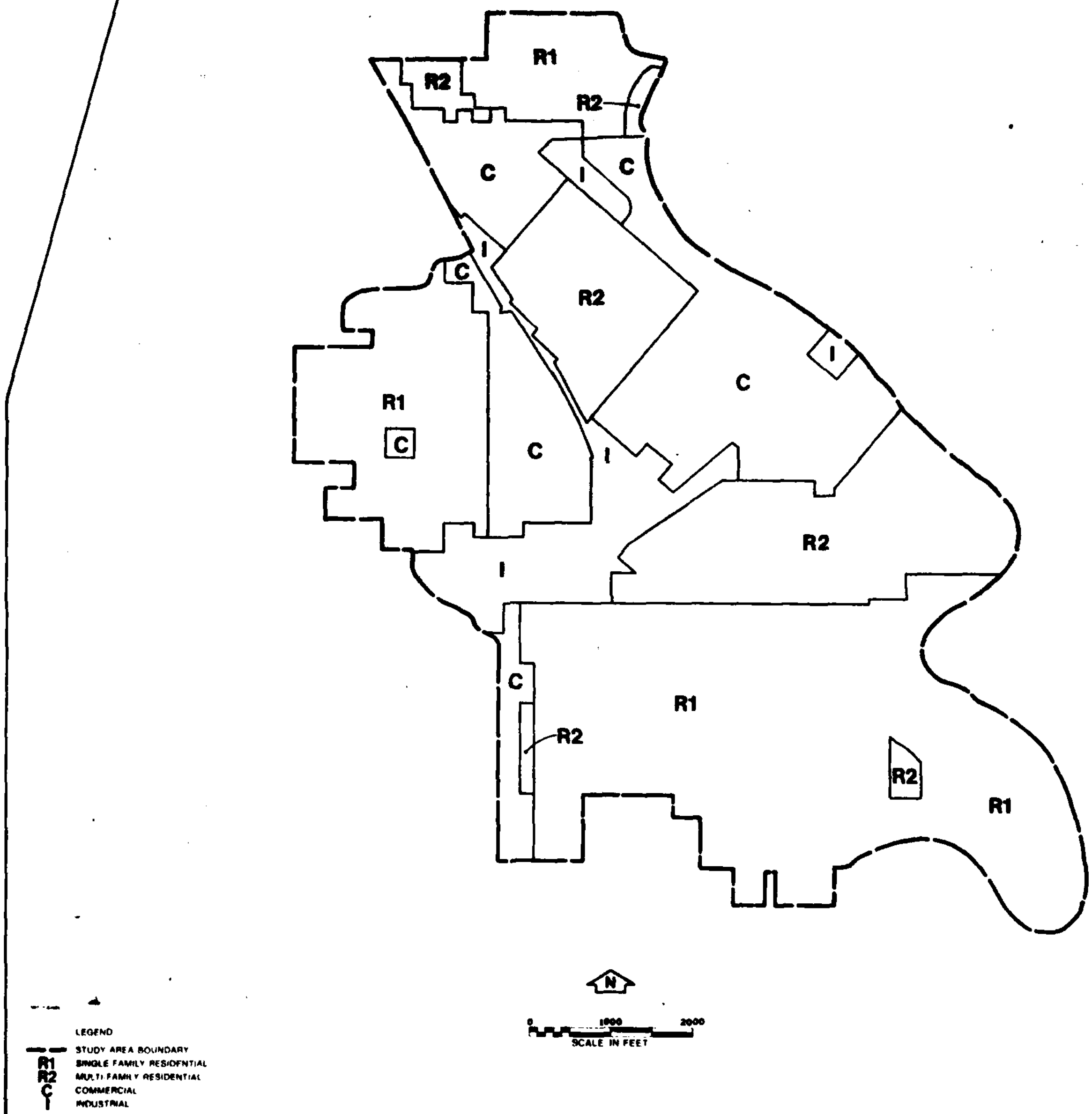

Figure 3 - Land Use Map

The flow of the locally significant streams--the Goose River, Turtle River, English Coulee, and the Grand Marais Coulee--and the network of drainage ditches is extremely variable, responding to local rainfall and snowmelt. All are fairly sluggish streams with low velocities of flow caused by the flat terrain. The 7-day, 10-year low flow of these surface water resources is at or near zero.

The average flow of the Red River of the North downstream of Grand Forks is approximately 2,500 cfs. A flow range from 2.4 cfs to 85,000 cfs has been recorded. This is based on 93 years of record at the U.S. Geological Survey gaging station.

Wastewater treatment facilities in the study area consist of controlled discharge lagoons which influence river flow and quality when they are discharging.

Uses of the Receiving Water

The Red River of the North basin is used extensively for a variety of purposes. Some of the uses include municipal and industrial water consumption, irrigation, recreation, and habitat for a variety of aquatic and terrestrial plants and animals.

Five comminities use the Red River of the North as their water source - Drayton, Fargo, Grand Forks, Dilworth, and Moorhead.(3) In addition to municipal water users, the food and kindred products industry has major water requirements, many of which are satisfied by surface water from the Red River.

An estimated 18,000 acres of cropland in the Red River basin are irrigated. Irrigated crops include corn, alfalfa, potatoes, sugar beets, and other lesser crops. These crops are irrigated under authorization provided by surface water permits issued for the Red River and its tributaries.

Deficiencies in recreation opportunities in the Red River Valley are apparent. The river's impaired water quality and

irregular flow have reduced its fish population; aesthetic value; and use for swimming, canoeing, and boating to such a degree that it presently provides only limited recreation use.

In general, the Red River does not provide good fishing opportunities. This condition has been attributed to a combination of poor water quality and the physical nature of the river which is not conducive to fish production. Steep banks, lack of reaeration during winter ice cover, stream water level fluctuations, and the unstable silty bottom tend to reduce the productivity of the river. Rough fish species are better adapted to these conditions and appear in greater numbers than game fish. There are, however, many local fishing hot spots, particularly in impounded waters behind low head dams and the downstream tailraces; catfish, sucker, walleye, northern pike, and drum are the sport fish commonly taken in these locations.

A woodland community occurs on the floodplain of the Red River and tributary streams. A variety of trees such as bur oak, hackberry, American elm, basswood, and green ash dominate the mature forest stands. There is generally a well-developed understory composed of small trees and tall shrubs. This ecosystem provides a diverse habitat for cottontail rabbits, deer, squirrels wood ducks, and associated species. A large number of waterfowl pass through the study area during spring and fall migrations. Scattered oxbow marshes and wetlands along the Red River provide refuge for these birds.

Surface Water Quality

Water quality data were collected from the Red River of the North and the Red Lake River between 1953 and 1976.(3)(4) The averages and ranges of certain of these water quality indicators are summarized in table 1. A review of the table indicates that many water quality indicators are fairly similar between the two rivers. The Red River of the North has more dissolved solids,

greater hardness and alkalinity, and greater extremes in suspended solids than does the Red Lake River. However, higher average biological values are found in the Red Lake River than the Red River of the North. Values may be lower at the present time because of increased municipal and industrial wastewater treatment upstream of the study area. At low Red Lake River flows, chemical constituents tend to have concentrations near the high end of the range shown in table 1.(5)

Both the Red Lake River and especially the Red River of the North have extensive periods of high turbidity. This turbidity is mainly due to the nature of the stream bed (very fine silty clay) and the slow settlement of the colloidal clay after turbulence from fluctuating stream levels and currents that suspend the clay in the river.(6)(7)

Pollutants discharged into the Red River affect the capability of the river to be utilized as a water resource. Some of the pollutants most commonly found in combined storm and sanitary sewer overflow that can degrade water quality include BOD, fecal coliforms, total suspended solids, floatables, nutrients, grease and oils, and heavy metals.

<u>BOD</u> - High BOD levels in a receiving water indicate the presence of organic wastes, which are oxidized by microorganisms. An influx of high BOD waste from a combined sewer overflow can, therefore, depress the dissolved oxygen levels in the receiving water. This can create a significant environmental impact by causing stress in organisms sensitive to dissolved oxygen levels.

<u>Fecal Coliform</u> - Fecal coliform bacteria are present in high numbers in combined sewer overflows. If allowed to enter a receiving water, these bacteria can degrade the recreational value of a water resource. Their presence indicates that domestic and/or animal wastes are present in the water. In addition, waterborne pathogenic organisms may be associated with fecal

Table 1 - Surface water quality in the study area

Constituent	Red Lake River[1] Average[3]	Red Lake River[1] Range	Red River of the North[2] Average[3]	Red River of the North[2] Range
Physical				
Flow (cfs)	779	75 - 6,530	1,562	310 - 5,470
Turbidity (FTU)	69	2 - 4,500	66	2 - 1,500
Color (units)	30	5 - 100	29	5 - 120
Total Solids (mg/1)	334	28 - 1,500	512	260 - 940
Suspended Solids (mg/1)	51	2 - 410	80	1 - 750
Biological				
Coliform Organisms (#/100 ml)	5,550	20 - 92,000	2,462	20 - 160,000
Fecal Coliform (#/100 ml)	950	20 - 23,000	155	20 - 4,900
Fecal Strep (#/100 ml)	220	10 - 1,100	170	9 - 800
Chemical				
Alkalinity (mg/1 as $CaCO_3$)	174	88 - 290	233	96 - 370
Hardness (mg/1 as $CaCO_3$)	202	130 - 300	298	140 - 460
Calcium (mg/1 as $CaCO_3$)	125	87 - 200	156	89 - 310
Magnesium (mg/1 as $CaCO_3$)	63	40 - 90	141	91 - 190
Arsenic (mg/1)	0.009	.001 - .010	0.010	.005 - .023
Barium (mg/1)	0.024	.012 - .050	0.024	.012 - .050

Table 1 - (Continued)

Constituent	Red Lake River[1]		Red River of the North[2]	
	Average[3]	Range	Average[3]	Range
Boron (mg/l)	0.048	.020 - .070	0.110	.080 - .180
Cadmium (mg/l)	0.013	.010 - .210	0.010	.010 - .012
Chromium (mg/l)	0.011	.002 - .020	0.012	.002 - .020
Chloride (mg/l)	5.0	0.5 - 18.0	16.7	1.5 - 40.0
Copper (mg/l)	0.012	.010 - .060	0.012	.010 - .040
Iron (mg/l)	1.31	.010 - 17.00	1.88	.04 - 18.0
Lead (mg/l)	0.013	.010 - .130	0.018	.010 - .420
Manganese (mg/l)	0.100	.010 - .640	0.132	.006 - 1.20
Mercury (mg/l)	0.0002	.0001 - .0008	0.0004	.0001 - .0025
Nitrate (mg/l as N)	0.23	.01 - 2.50	0.50	.02 - 4.70
Selenium (mg/l)	0.006	.001 - .010	0.006	.001 - .010
Silver (mg/l)	0.004	.002 - .010	0.005	.002 - .010
Sulfate (mg/l)	28	9 - 81	40	29 - 180
Zinc (mg/l)	0.064	.010 - 2.8	0.032	.010 - .270

[1]At bridge on State Highway 220 at East Grand Forks.
[2]At Grand Forks Waterworks Intake.
[3]Average values when sampled or average value of samples.

Source: Reference (5).

coliforms. It is generally recognized that swimming is unacceptable in water where the fecal coliform bacteria level exceeds 200 per 100 ml. Fecal coliform levels have exceeded this level in the Red River at Grand Forks/East Grand Forks.

Total Suspended Solids - High levels of TSS are found in the Red River. Suspended solids interfere with the recreational use and aesthetic enjoyment of the water. As turbidity levels decrease, the water becomes more desirable for swimming and other water contact sports. Settleable solids blanket the bottom of the stream, preventing spawning and the development of a desirable benthic population. High levels of suspended solids will reduce light penetration which limits photosynthetic activity.

Floatables - Material that floats may enter a combined sewer overflow and be discharged into a receiving stream. Paper, cans, bottles, other manmade articles, sticks, and leaves constitute floatable material. This material impairs the aesthetics of the river and may collect along shorelines, in backwaters, and on intake structures.

Nutrients - Nutrients, particularly phosphorous, promote eutrophication of a receiving water body. Algae and other nuisance plant growths may result. This condition could occur in the Red River of the North, particularly during low-flow periods.

Grease and Oils - These materials create aesthetic problems associated with floating scum on the water surface. Taste and odor problems may arise when the receiving water is used for drinking water supplies. Grease and oils may enter the combined sewer overflow as runoff from streets and parking lots.

Heavy Metals - Metals may accumulate in the tissues of man and other animals. At various levels, they can become toxic to aquatic organisms and can enter domestic drinking water supplies if not properly treated.

Urban Runoff Flow

The "rational" method has been used to estimate peak stormwater flow rates for this study. The rational formula is written as follows:

$$Q = cia$$

Where Q is the peak flow rate in cubic feet per second (cfs), c is the runoff coefficient, i is the rainfall intensity in inches per hour, and a is the drainage area in acres. The runoff coefficient is estimated to be 0.4 for residential portions of the study area and 0.85 for commercial areas. The rainfall intensity is dependent upon the storm frequency being used for design and the time of concentration for the drainage area. An intensity-duration-frequency curve has been developed for the study area and is shown on figure 4. Peak flow rates were calculated throughout the system to determine the adequacy of existing facilities and to size new facilities, such as storm sewers, which must carry peak flow rates. Table 2 lists peak flow rates, at the outfall, for each service area for several different frequency storms.

Several different frequency 2-hour design storms were developed for use in this study. The design storms were developed from data contained in U.S. Weather Bureau Technical Paper 40.(12) As a check, design storms were also developed from 10 years of daily rainfall records which were obtained from the National Oceanic and Atmospheric Administration for the Grand Forks FAA station. Total rainfall volume for 10-year, 1-year, 0.5-year, and 0.25-year 2-hour design storms are shown in table 3. Rainfall amounts developed from the U.S. Weather Bureau (now the National Weather Service) information give slightly higher results than those developed from the 10 years of rainfall records. These rainfall amounts have been used for this study since they are based on a longer period of record and will give slightly more conservative results. One reason for lower rainfall values

Table 2 - Peak stormwater flow rate

Service Area	Drainage Area (Acres)	Estimated Peak Flow Rate into Red River[1]				
		0.25-Year Storm (cfs)	0.5-Year Storm (cfs)	1-Year Storm (cfs)	5-Year Storm (cfs)	10-Year Storm (cfs)
1	88	33	42	49	77	91
2	307	96	110	135	221	258
5	139	52	64	76	121	143
6	316	105	126	152	240	303

[1]Theoretical flow rate if not restricted by existing sewer sizes.

Source: Stanley Consultants

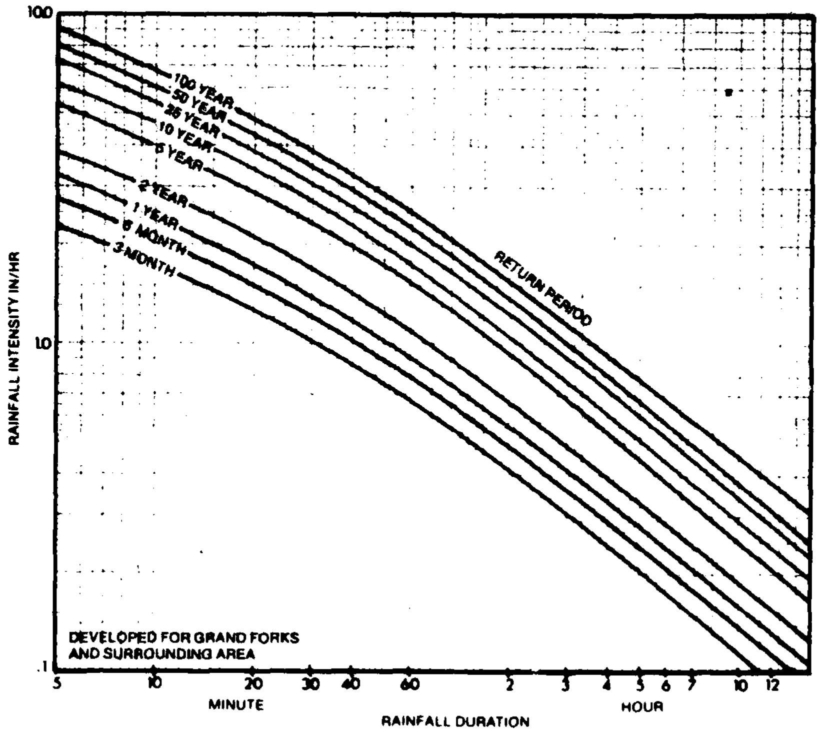

Figure 4 - Rainfall Intensity - Duration - Frequency Curves

SOURCE STANLEY CONSULTANTS AND REFERENCE (12)

obtained with the 10 years of data may be due to the fact that rainfall at the gaging station averaged about 10 percent below normal during the 10-year period when the records were collected.

It is necessary to determine the volume of combined sewer overflows in order to estimate the quantity of pollutants discharged into the Red River of the North and to size and cost facilities to treat the overflows. The amount of rainfall which will appear as runoff is dependent upon several variables including ground cover, slope, soils type, antecedent precipitation, and other similar factors. In the combined sewer area it is anticipated that, on the average, approximately 60 percent of

Table 3 - 2-hour design storms

Frequency	Rainfall Quantity (inches): U.S. Weather Bureau TP 40[1]	Rainfall Quantity (inches): NOAA Data[2]	Probability Equaled or Exceeded In Any 1 Year
10-year	2.0	1.9	.10
1-year	1.1	.95	1[3]
0.5-year	0.9	.8	2[3]
0.25-year	0.7	.6	4[3]

[1]Developed from reference 12 and used in this report.
[2]Developed from 10 years of local rainfall data.(13)
[3]Probable number of events in any one year.

Source: Stanley Consultants

the rainfall will be collected by the combined sewer system. Only a small portion of the stormwater runoff is pumped to the wastewater treatment plant as described in following sections of this report. Therefore, the combined sewer overflow quantity can be approximated by the stormwater runoff volume. The estimated volume of combined sewer overflow for each service area for several frequency storms is shown in table 4.

EXISTING COLLECTION SYSTEM

Combined Sewers

The existing combined sewer system as shown on figure 5 surrounds the downtown area of Grand Forks and covers approximately 850 acreas. The study area boundary is defined by combined sewer areas and excludes a central area of the city where the sewer system is separated or is in the process of being separated. The remainder of the city was originally built with separate sewer systems.

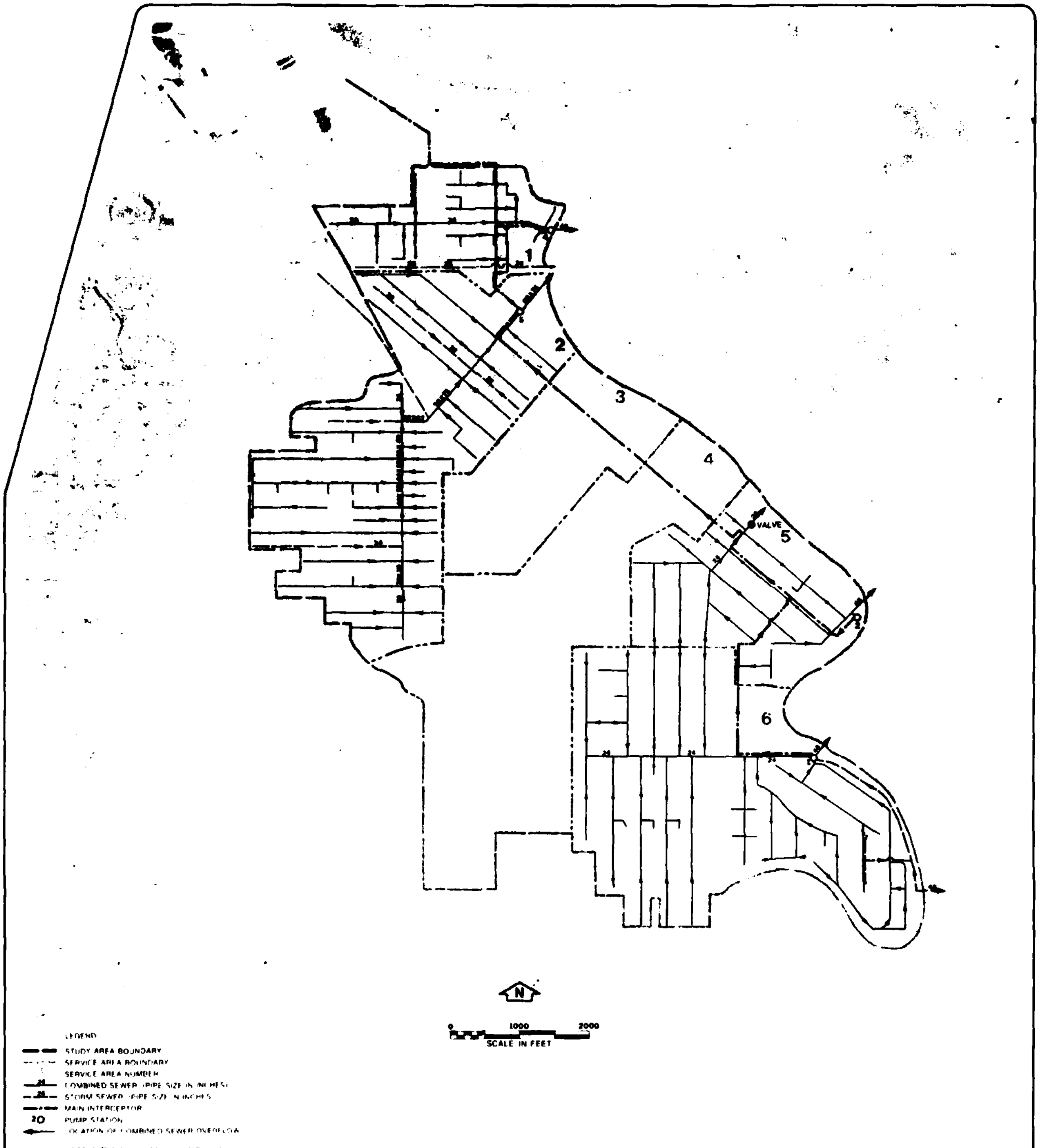

Figure 5 - Existing Combined Sewer System

Table 4 - Combined sewer overflow volume

Service Area	Drainage Area (Acres)	Estimated Volume of Combined Sewer Overflow (million gallons) 0.25-Year 2-Hour Storm	0.5-Year 2-Hour Storm	1-Year 2-Hour Storm	10-Year 2-Hour Storm	Total for Average Year[1]
1	88	1.0	1.3	1.6	2.9	28.7
2	307	3.5	4.5	5.5	10.0	100.0
5	139	1.6	2.0	2.5	4.5	45.3
6	316	3.6	4.6	5.7	10.3	103.0
Total	850	9.7	12.4	15.3	27.7	277.0

[1] Based on average annual rainfall of 20 in/year.

Source: Stanley Consultants

Sanitary lines which are part of a noncombined system but feed into the combined system are not included in the study area. However, flow from these systems must be considered when developing new sanitary sewer alternatives. Similarly, storm sewer flows that feed into the combined sewer system but are part of a noncombined system must be considered and included in combined sewer flows. This is the case with a storm collector that runs south along Washington Street from Gateway Drive to 8th Avenue North and feeds into the main combined line on 8th Avenue North. Another storm sewer of special consideration is the collector that runs east along Gateway Drive. This storm flow can be excluded from the total storm flow in the combined sewer area because it outfalls directly to the Red River of the North.

Combined sewer capacities were estimated on the basis of known line sizes and slopes. Estimates were made using Manning's equation with a roughness coefficient (n) of 0.013. Table 5 lists the capacities of the existing combined sewers near each overflow structure. Capacities were also calculated at other points to determine the adequacy of the existing system. The storm recurrence level that the existing collection system can handle is also shown in table 5. Storms which exceed the capacity of the existing collection system result in temporary street flooding and basement backups.

No formal records are kept of the number of houses which experience basement backups. Discussions with city officials indicate that basement backups occur in each service area. Service Areas 2 and 6 experience the most severe sewer backup problems with many basements flooded during heavy rains. The areas located west of North Washington Street in Service Area 2 and west of Belmont Road in Service Area 5 experience the worst problems. Calculations indicate low combined sewer capacities in these areas and substantiate the reported sewer backup problem.

Table 5 - Combined sewer capacities

Service Area	Pipe Size (in)	Slope (ft/100 ft)	Capacity (cfs)	Design Storm[2] (year)
1	48	.22	69	5
2	58 x 75	.15	130	1
5 to valve	24	.2[1]	10	.5
to lift station #2	48	.2[1]	65	.5
6	48	.2[1]	65	<.25

[1]Assumed slope.

[2]Approximate design storm capacity of existing system.

Source: Stanley Consultants

Most of the affected houses located in these two areas are reportedly protected by sewer valves, backwater valves, or plugs in lower elevations of the buildings. However, many backups still occur from sudden storms or when the owner is not at home to operate his valve or other protective device.

Main Interceptor

The main interceptor in the study area parallels the Red River of the North, collecting combined sewage and transporting it to the wastewater treatment plant. The main interceptor is predominantly a force main, but in some areas, such as in the downtown vicinity, it is a gravity collector.

Combined Sewer Overflow Structures

Overflow structures in the study area are located at six points as shown on figure 5. Overflow structures consist of 12- and 18-inch pipes tapped into the bottom of the main combined sewers. Weirs 12 to 15 inches high in the combined sewer contain low

flow and divert it into the 12- and 18-inch pipes which carry it to the lift stations. The flow is then pumped into an interceptor which takes it to the wastewater treatment plant.

Figure 6 shows the relative elevations of the combined sewer overflow system for Service Area 2. The other service areas have similar overflow systems. The normal pool elevation and several different frequency flood elevations are also shown on figure 6.

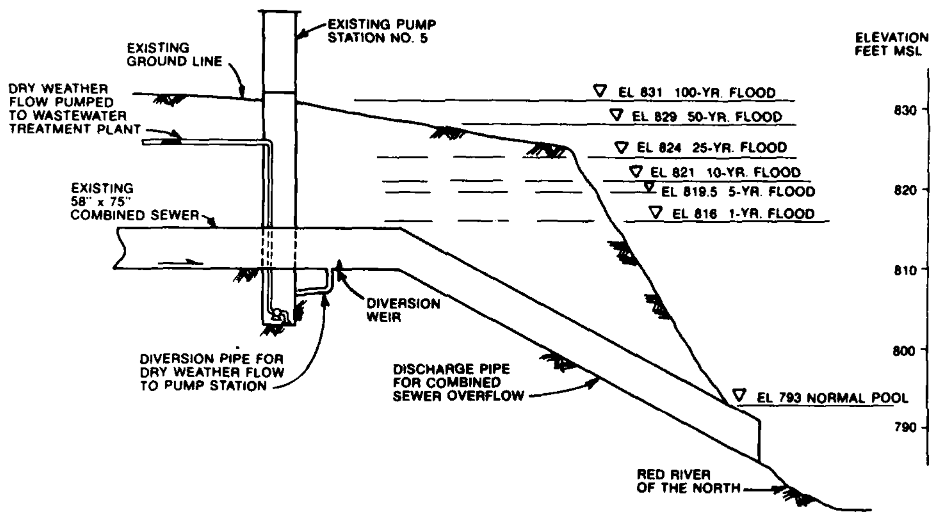

Figure 6 - Service Area 2 - Section of Combined Sewer Overflow

The normal pool elevation of the Red River of the North is maintained by a low head dam located in the river downstream from the combined sewer area. As shown on figure 6, the combined sewer overflow discharge is located below normal water level making it difficult to observe overflow events.

<u>Lift Stations</u>

During storms, the factor that limits the volume of combined sewage sent to the wastewater treatment plant is the capacity of the lift stations. There are four lift stations in the study area. Two overflow structures are associated with the lift

station in study area 6. One of these overflows is the outfall of a storm sewer and is used as an overflow after the first overflow structure capacity is surpassed. Two overflows are also located in Area 5. Area 1 and Area 2 each contain one overflow structure.

Table 6 lists lift station capacities, calculated sanitary flows, and the corresponding rainfall intensities that will cause overflow. As the data show, a small amount of precipitation can cause overflows. However, a light rainfall following a dry period may not cause an overflow event since much of the rainfall will be lost through interception and depression storage before runoff will occur. Also, the intensity indicated will cause overflow only if sustained for a period of time greater than the time for the rainfall runoffs to reach the overflow structures.

A review of table 6 indicates that pump stations 4, 5, and 1 have apparently been designed with very low peaking factors. The calculated average sanitary flow rate is based upon 80 gallons of sanitary flow per capita per day plus an infiltration allowance of 10,000 gallons per mile per day for all sewer mains and house services. There are no flow meters or hour meters installed at any of the four pump stations so the amount of flow which is pumped or the number of hours per day that the pumps operate is not known.

Discussions with city officials and sewage department personnel indicate that there are no known cases of dry weather overflows at any of the pump stations. The firm pumping capacity listed in table 6 has been calculated assuming that the largest pump is out of service. The pumps are very rarely out of service and the pumping capacity which is normally available is 50 to 100 percent greater than the firm capacity listed.

Table 6 - Lift station flows and capacities

Service Area	Lift Station	Area Served (Acres)	Firm Pumping Capacity (cfs)	Calculated[1] Average Sanitary Flow (cfs)	Allowable Storm Flow Before Over-flow (cfs)	Rainfall Intensity for Overflow (cfs)
1	4	88	0.27	0.22	0.05	< 0.1
2	5	1,009[2]	4.04	2.81	1.19	< 0.1
5	2	31[3]	0.45	0.06	0.39	< 0.1
6	1	316	1.45	0.67	0.78	< 0.1

[1] Based on 80 gallon per capita per day plus infiltration allowance of 10,000 gallons per mile per day for sewer main and house services.

[2] Lift station 5 serves Areas 2, 3, and part of 4, and repumps flow from Areas 5 and 6.

[3] Lift station 2 serves only part of Area 5.

Source: Stanley Consultants

The pumping stations were constructed approximately 20 years ago and are generally in good condition. Electrical switchgear has been replaced in several of the pump stations and several of the pumps were reconditioned following the severe floods in the spring of 1979. None of the pump stations are equipped with standby power and power outages could cause raw sewage to be bypassed to the river.

If new sanitary sewers are constructed, the quantity of infiltration may be reduced somewhat from the estimated values in table 6. Flow measurements will be required following sewer separation to determine if the pump stations have adequate peaking capacity for the new flow conditions. Pump station 2 in Area 5 is located in Central Park on the river side of the levee and is subject to flooding each spring. This pump station should either be flood proofed or replaced with a new pump station located on the dry side of the levee.

Combined Sewer Overflow Quanity

The estimated quantities of combined sewer overflow for several frequency storms were presented in table 4. Based on a mean annual precipitation of 20 inches per year, combined sewer overflow is estimated to average approximately 277 million gallons per year.

Combined Sewer Overflow Quality

The quality of combined sewer overflow varies considerably from storm to storm and also from time to time during the duration of a single storm. The water quality is usually poorest during the early part of a storm as pollutants are washed off streets and scoured loose from the sewer system. Because of the relatively wide variation of BOD values which are typically found in combined sewer overflows at Grand Forks. The combined sewer overflow quality can be estimated based on data extracted from other reports.

An extensive literature search of existing combined sewer overflow quality data was conducted for this study. The information shown in table 7 was extracted from a U.S. EPA report on urban stormwater management and technology. Data contained in the U.S. EPA report were developed from a broad data base and the combined sewer overflow quality values agreed very well with most values reported in other literature sources.

Table 7 - Typical combined sewer overflow quality and comparison data

	TSS (mg/l)	BOD (mg/l)	COD (mg/l)	Total Nitrogen (mg/l)	PO_4-P (mg/l)	Lead (mg/l)	Fecal Coliforms (organisms/100 ml.)
Combined Sewer Overflow							
Typical Values	370	115	375	9	1.9	0.37	670,000
Range of Values	270-540	57-230	260-480	4-17	1.3-2.8[1]	0.15-0.6	200,000-1,200,000
Sanitary Sewage							
Typical Values	200	200	500	40	10	--	--
Storm Water Runoff							
Typical Values	415	20	115	3	0.6	0.35	13,500
Stream Background Levels							
Typical Values	5-100	0.5-3.0	20	0.05-0.5	0.01-0.2[1]	<0.1	--

[1]Total phosphorus as P.

Source: Reference (8).

Very little information on combined sewer overflow quality is available for Grand Forks. However, one set of sampling data was provided by the city. Samples were collected and analyzed in a combined sewer manhole for an intermittent storm on 28 June 1979. Samples were collected at half hour intervals for a period of three hours. Total rainfall was reported to be 1/4 to 1/2 inch. Suspended solids values averaged 460 mg/l starting at 960 mg/l at the beginning of the storm and dropping to 160 mg/l at the end of 3 hours. BOD values varied throughout the storm with

an average of 126 mg/l and a range from 83 mg/l to 239 mg/l. Fecal coliform values varied from 1,500,000 to 2,400,000 organisms per 100 milliliters.(4) With the exception of fecal coliform, these results compare quite well with the U.S. EPA values shown in table 7. The typical values shown in table 7 have been used to estimate waste loadings from the combined sewer area and pollutant reductions which could be achieved by the construction of a separate sewer system.

Using typical combined sewer overflow waste concentrations from table 7 and an average annual discharge of 277 million gallons, the estimated BOD load from the combined sewer overflows is 265,700 pounds per year and the total suspended solids load is 855,000 pounds per year. Although the actual waste load to the Red River of the North may vary somewhat from these values, they do indicate the potential significance of the pollution load from the combined sewer area.

Infiltration and Inflow

The purpose of an infiltration/inflow analysis is to demonstrate the absence or presence of excessive infiltration/inflow in a sanitary sewer system. The existing combined sewer system was designed to collect storm runoff as well as sanitary sewage. Therefore, if the existing system is maintained as a combined system it would not be logical to conduct an infiltration/inflow analysis on the existing system. If the selected plan consists of sewer separation with use of the existing combined sewer system to transport only wastewater, it will be necessary to conduct an infiltration/inflow analysis on that part of the system used for sanitary service. Rules guiding how an infiltration/inflow analysis is to be conducted are given in 40-CFR-35.927. The U.S. EPA has defined infiltration/inflow as follows:

> Infiltration - The water entering a sewer system, including sewer service connections, from the ground, through such means, as, but not limited to, defective

pipes, pipe joints, connections, or manhole walls. Infiltration does not include, and is distinguished from, inflow.

Inflow - The water discharged into a sewer system, including service connections from such sources as, but not limited to, roof leaders, cellar, yard, and area drains, foundation drains, cooling water discharges, drains from springs in swampy areas, manhole covers, cross connections from storm sewers, and combined sewers, catch basins, storm waters, surface runoff, street wash waters, and water drainage. Inflow does not include and is distinguished from, infiltration.

There are reportedly many downspout connections to the combined sewer system. If the existing combined sewer system is to be used as a sanitary sewer system, these downspouts and all catch basins and other direct connections will have to be disconnected from the combined sewers. Downspout work is generally the responsibility of the private owner.

If an infiltration/inflow survey is conducted and indicates excessive infiltration/inflow, it will be necessary to conduct a sewer system evaluation survey (SSES). The SSES is a systematic examination of the sewer system to determine the specific location, estimated flow rate, method of rehabilitation, and cost of rehabilitation versus cost of transportation and treatment for each defined source of infiltration/inflow. An SSES includes such items as a flow monitoring program, manhole inspections, floodwater testing, smoke testing, and sewer televising.

A limited infiltration/inflow analysis conducted in Grand Forks in 1975 determined that both infiltration and inflow occur. Inflow is the more significant problem whenever there is any appreciable precipitation.(9)

FUTURE CONDITIONS

PLANNING PERIOD

This stage 3 study develops detailed planning information to help solve the combined sewer overflow problem in Grand Forks. The planning period used in the Grand Forks urban study is 50 years and continues through the year 2030. The planning period, as defined by the U.S. EPA is "the time span over which wastewater management needs are forecast, facilities are planned to meet such needs, and costs are amortized."(10) Federal regulations specify that the planning period for wastewater treatment systems extend 20 years beyond the estimated date of initial system operation. A 20-year planning period was used for this study. However, since the study area is completely developed, design conditions are not anticipated to change significantly over the next 50 years. The design life of certain structures, such as sewers, is greater than 20 years and the additional life is taken into consideration during the economic analysis.

LAND USE

Most of the combined sewer area is presently developed and little change is anticipated during the next 20 years. The study area is predominantly residential with some localized commercial development. Future years could possibly show some replacement of older residences with new single or multiple family housing.

DEMOGRAPHIC PROJECTIONS

Since the combined sewer area is fully developed, the population is not expected to change significantly during the

20-year planning period. A slight increase in population may be realized due to the construction of some multiple family housing in place of older single family residences. Land use patterns are expected to remain essentially as they are at present.

FORECAST OF FLOW AND WASTE LOADS

Future flow and waste loads from the combined sewer area are not expected to increase significantly since the combined sewer area is fully developed. Sewer separation would reduce the volumes of flow reaching the wastewater treatment facilities from the area presently served by combined sewers. Also, the discharge of untreated sanitary wastes to the Red River of the North would cease if the sewers were separated.

FUTURE ENVIRONMENT WITHOUT THE PROJECT

The future environment without the project is anticipated to be similar to that which exists at the present time. Combined sewer overflows may cause occasional periods of poor water quality in the Red River of the North. Large quantities of pollutants, including solids, organics, nutrients, bacteria, and floatables, will be discharged to the river during overflow events. Organic materials deposited in the river will exert an oxygen demand and may cause water quality violations during low flow periods. Pollutants carried into the Red River of the North with the combined sewer overflows have an adverse impact on the water quality of the Red River and, therefore, on the municipal water supply.

Sewage discharged to streams can cause diseases to be transmitted to people by the ingestion of polluted water or food contaminated by flies or other insects.

FORMULATION OF ALTERNATIVES

GENERAL

The development of alternatives began with the division of the study area into service areas. Service areas are areas drained by one main trunk line. Area 5 is an exception in that it is made up of two smaller drainage areas.

Each service area is predominantly of the same population density. Population densities have been estimated in order to calculate sanitary flows. Table 8 lists service areas and their respective acreages and population densities.

Table 8 - Service area data

Service Area	Acreage	Population Density (Persons/Acre)
1	88	12.5
2	307	13.0
5	139	11.2
6	316	11.2

Source: Stanley Consultants

The following alternatives are developed and considered in this report:

- Combined sewer separation.
- Overflow detention with treatment.
- Swirl concentrator treatment.
- Relocate water intakes.

- No action plan.
- Collection system management.
- Source management.

The last two alternatives, collection system and source management, are considered in conjunction with and to complement the other alternatives. Other alternatives were considered but were eliminated from further evaluation based on a preliminary analysis. These are discussed further in the following section.

PRELIMINARY SCREENING

During the preliminary screening of alternatives, an effort was made to eliminate those alternatives which were impractical because of operational difficulties, environmental unacceptability, or excessive high cost. The following alternatives have been eliminated from further consideration for the reasons listed below.

Flow Reduction

Sources of flow in the combined sewer system are sanitary wastes, stormwater runoff, and infiltration and inflow. Sanitary wastes are predominantly residential and commercial. Any sanitary waste flow reduction that could be implemented would probably have an insignificant impact on the total combined sewer flow. Reduction in infiltration could noticeably reduce dry weather flows which require treatment but would have an insignificant effect on combined sewer overflows. The volume of stormwater entering the combined sewer system could be reduced by diverting overland runoff out of the study area or by construction of separate storm sewers. Overland drainage would be difficult if not impossible because of the very limited topographic relief and the existing street development in the study area. A separate storm sewer system is being developed as a separate alternative. Because of the impracticability and difficulty of reducing flow rates in the combined sewers, these considerations were eliminated as feasible alternatives.

Combined Relief Sewers

Construction of a combined relief sewer system would reduce flooding, but it would not reduce combined sewer overflow quanities or the waste load on the Red River of the North. Because of the limited benefits and relatively high costs of this alternative, it was eliminated from further consideration.

In-System Storage

The storage capacity of the existing combined sewer system is incapable of handling any significant storm event. Areas 5 and 6 are especially limited in their available capacity, as shown in table 5. Because of the inability of the existing system to handle any significant event, this alternative was eliminated from further consideration.

Treatment in Existing Treatment Plant

The existing wastewater treatment plant consists of a wastewater lagoon system with 180-day detention. To treat the combined sewer overflow in the lagoon system, total detention would be required near the existing overflows with the wastewater pumped to the lagoons after the storm is over. This means that, in addition to storage volume, expanding the lagoon system is necessary. The costs associated with these requirements make this alternative not cost effective; therefore this alternative is eliminated from further consideration.

Filtration or Sedimentation Without Equalization Storage

Filtration or sedimentation with storage is included as one of the developed alternatives. Treatment without equalization storage would require very large treatment facilities to accommodate peak flow rates. Because of this size requirement and the cost associated with it, sedimentation or filtration without equalization storage was eliminated from further analysis.

COMBINED SEWER SEPARATION ALTERNATIVES

The following four combined sewer separation alternatives were considered:

1. A new sanitary sewer system, retaining the existing combined sewer as a storm sewer system.
2. A new storm sewer system, retaining the existing combined sewer as a sanitary sewer system.
3. Incorporating appropriate parts of the existing combined system in a sanitary sewer system, supplemented by new sanitary sewers as needed; and likewise for a storm sewer system.
4. A new sanitary and a new storm sewer system, abandoning the existing combined sewer system.

Following is a detailed description of these alternatives.

Alternative 1 - New Sanitary Sewer System

A new sanitary sewer system was developed to parallel the existing combined system. Existing house services must be connected to the new system and disconnected from the existing combined sewer system. Because existing house services will be used, it is necessary to place new sanitary lines in the same streets as the existing system.

Sanitary sewer flow rates are made up of two items:

1. Domestic flows estimated by the number of persons served assuming 80 gallons per capita per day; because the study area is fully developed, sizing for population projections was not necessary.
2. Infiltration estimates based on 10,000 gallons per day (gpd) per mile of sewer main and house services.

The sum of the domestic flows and the infiltration is the total sanitary sewerage flow reported in either gallons per minute (gpm) or cubic feet per second (cfs). A sliding peaking factor was used to estimate peak flow rates based on drainage area

population. For populations of 1,000 or less, a peaking factor of 5 was used. The factor decreases as population increases. Manning's equation was used to calculate line sizes using a roughness coefficient (n) of 0.013. Because of the flat slopes in the study area, 8-, 10-, and 12-inch lines were placed at minimum slope with larger lines placed at a slope of 0.2 percent. The proposed new sanitary sewer system, as shown on figure 7, is made up of 8-inch lines for branches with sizes up to 18 inches required for the main lines.

The new sanitary sewer system will transport the sanitary sewerage to existing pump stations where it will be pumped through the existing main interceptor to the wastewater treatment plant.

Alternative 2 - New Storm Sewer System

In developing a new storm sewer system, the goal was to provide drainage from all existing catch basins. It was assumed that existing catch basin locations are adequate to provide drainage in the study area. The new storm sewer system was developed to collect all existing catch basin drainage in the most efficient manner using natural drainage patterns.

The rational method was used to calculate storm flow rates. The study area is predominantly residential with some localized commercial areas. The runoff coefficient was estimated to be 0.4 for residential areas and 0.85 for commercial areas. The proposed system was sized for a 10-year storm and the peak flow rate from each service area is shown in table 9. Although the peak discharge rate into the Red River will increase, the total volume of water discharged will remain unchanged.

Figure 8 shows the proposed new storm sewer system. Pipe sizes range from 12- to 78-inch. Because of the large volume of stormwater to be transported within the study area, more than one main collector was used in some areas to help minimize the

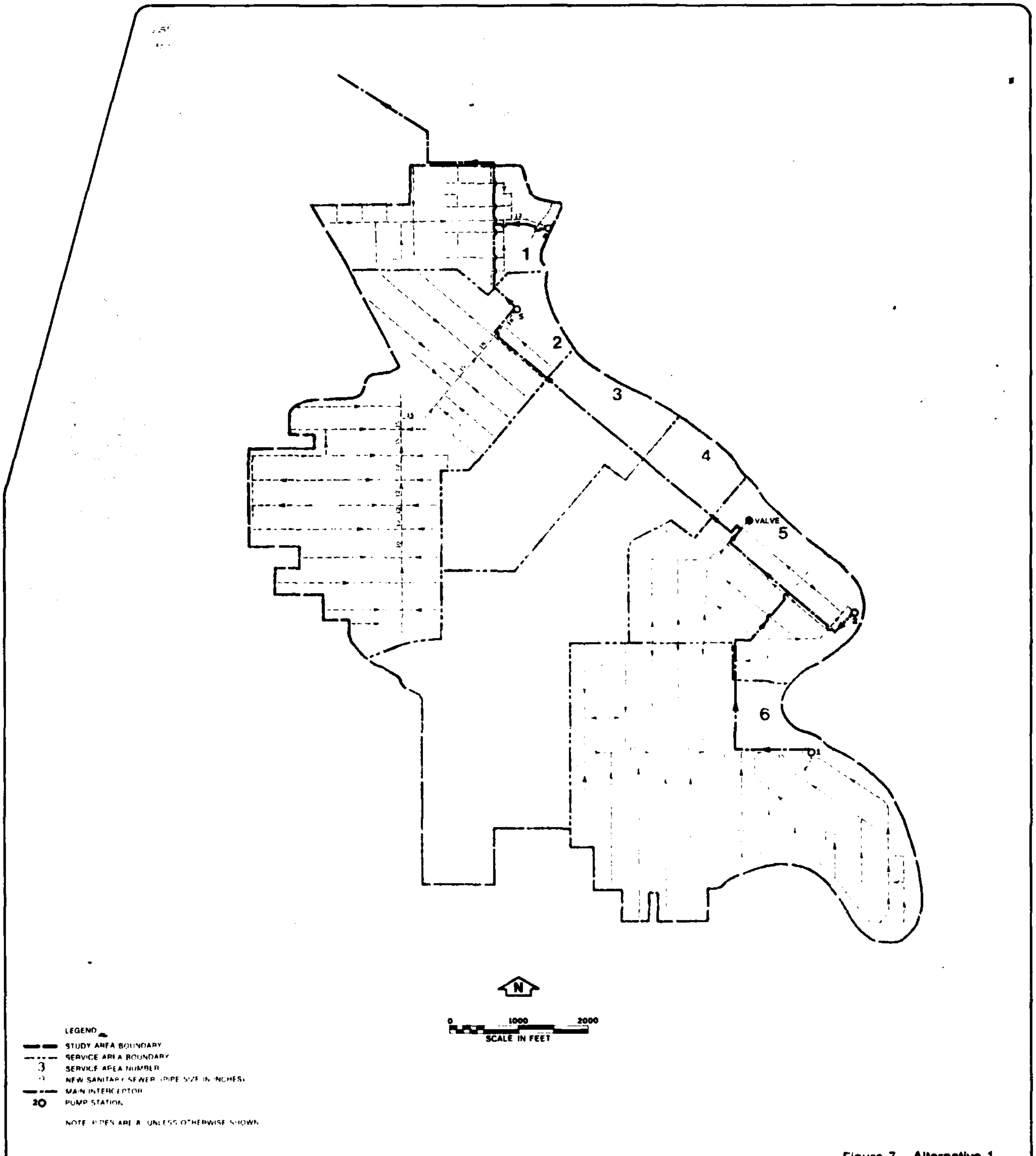

Figure 7 - Alternative 1
New Sanitary Sewer System

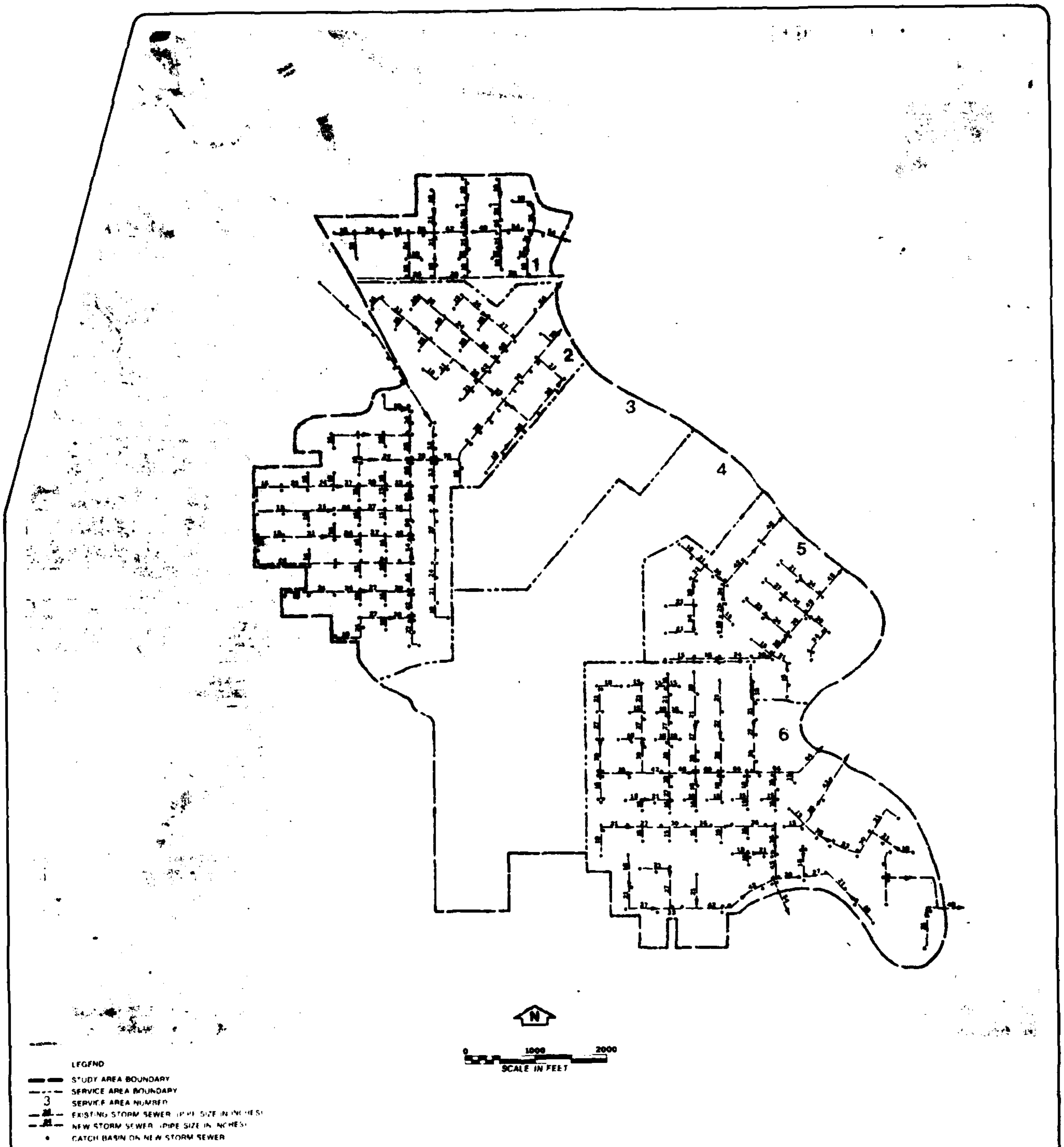

Figure 8 - Alternative 2
New Storm Sewer System

Table 9 - Peak storm flow rates by service area
based on 10-year storm

Service Area	Area (ac)	Flow Rate (cfs)
1	88	91
2	307	[illegible]58
5	139	143
6	316	303

Source: Stanley Consultants

use of large diameter pipes. Head wall structures were used at outfall points.

Alternative 3 - New Sanitary and New Storm Systems - Utilizing Existing

After new sanitary and storm sewer systems were developed, some compromises in the use of portions of the existing combined system for both sanitary and storm sewer systems became evident. In developing these compromises, the goal was to reduce costs and increase benefits. Figure 9 shows the proposed sewer system for alternative 3.

sewer, as compared to a new sanitary sewer, it is generally good practice to retain the combined sewer system for storm sewer where possible. This helps to alleviate the higher cost associated with the larger storm sewer sizes. The first step taken in developing this alternative was to determine the adequacy and problem points of the existing system. Table 10 lists the level of protection in terms of storm recurrence level provided by the existing system and by the proposed system. It should be noted that these capacities are on the main lines only and the capacities of branches may be somewhat less, resulting in some localized street flooding.

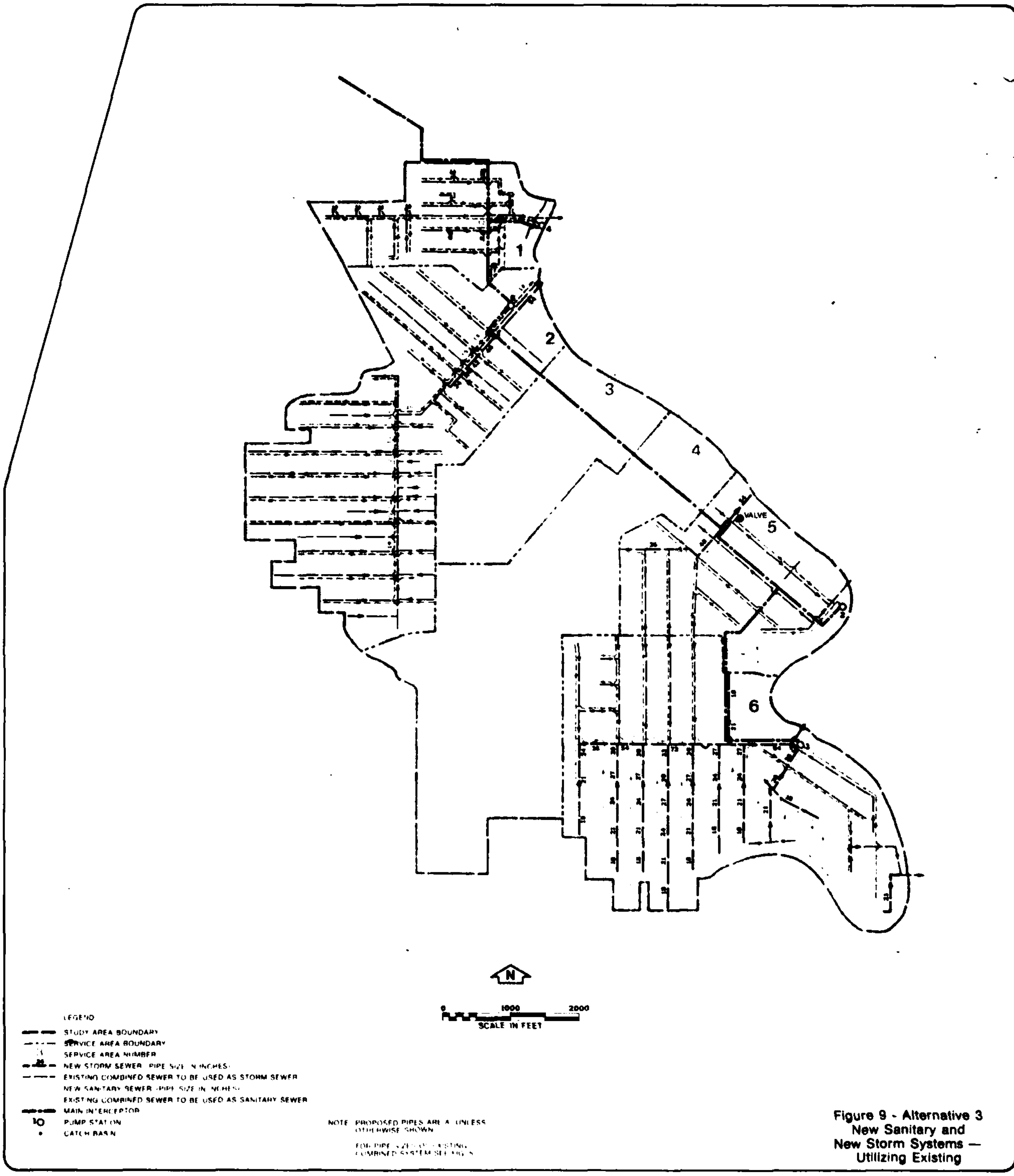

Figure 9 - Alternative 3
New Sanitary and
New Storm Systems —
Utilizing Existing

Table 10 - Level of protection by storm recurrence level

Service Area	Level of Protection Provided (Year Storm)	
	Existing System	Proposed Combination Alternative
1	5	5
2	1	3
5	0.5	10
6	<0.25	10

Source: Stanley Consultants

The Service Area 1 combined sewer system provides an adequate level of drainage allowing full use of the existing combined sewer system as a storm sewer. This requires a new sanitary sewer, which makes this alternative the same as alternative 1 for Service Area 1.

Service Area 2 has one major problem area. The main line approaching the outfall is undersized for storm drainage, forming a bottleneck. Upstream of the bottleneck the system has the capacity for a 3-year storm. If a portion of the stormwater loading is diverted by another line, the capacity of the overall system could be increased. To do this, a new storm sewer parallel to the existing 58-inch by 75-inch line is proposed. The extreme upstream end of the main line does not quite provide the capacity of the overall system; it provides capacity for about a 2-year storm. Also, many branches connected to the main line are somewhat undersized, having capacity for less than a 6-month storm. New sanitary sewers would be used where the existing combined system is converted to use as a storm sewer.

Service Area 5 presented a similar situation as Service Area 2. The main line approaching the outfall is undersized for

a storm sewer. It is proposed to construct a new main line storm sewer and use it in conjunction with the remainder of the existing combined system as a storm sewer system. The existing main combined line will be used as a sanitary sewer, along with new branches. This proposed system would greatly increase storm carrying capacity.

The existing system in Service Area 6 is undersized for storm sewer service, as indicated in table 10. Service Area 6 has an additional problem in that the existing system south of the main line is located in alleys, and it would be difficult to construct a parallel sewer in these alleys. Also, because of the inadequacy of the existing line as a storm sewer, it was decided to construct new storm sewer laterals in the streets in the area south of the main line. In addition, it is proposed to construct a new main storm sewer collector with sufficient capacity for larger storm events. Existing combined sewers located north of the main line would be converted for storm sewer use. The remaining existing combined sewers would be used as sanitary sewers and new sanitary sewers would be constructed north of the main line.

Alternative 4 - New Sanitary and New Storm Systems - Abandoning Existing

A fourth alternative for separating the existing combined sewer system is to construct both new sanitary and new storm sewers, abandoning the existing system. This alternative is essentailly the same as alternative 1 plus alternative 2. The only difference would be that the existing combined system would no longer be used.

OVERFLOW DETENTION WITH TREATMENT ALTERNATIVES

The major wastewater related problem in Grand Forks is the combined sewer overflow during storm events. If combined sewer flows can be retained, treated, and then released, the overflow

problem can be reduced by improving the quality of the discharged water.

Alternatives 5 and 6 - High Rate Filtration Treatment

These two alternatives consist of flow equalization in storage basins followed by high rate filtration treatment and disinfection as shown by the schematic on figure 10. A pumping station is required to pump flow from the storage basins through the filtration plant. Dual media filters are generally used; polyelectrolytes and coagulants may be used to enhance the removal of suspended solids, BOD, chemical oxygen demand (COD), and phosphorus. Chlorination facilities would be used following the filters to reduce coliform counts before the water is discharged to the Red River. Solids loading rate is a prime consideration for optimum design and operation of high rate filtration treatment systems. A solids loading rate of 20 gpm per cubic foot was used for this study.

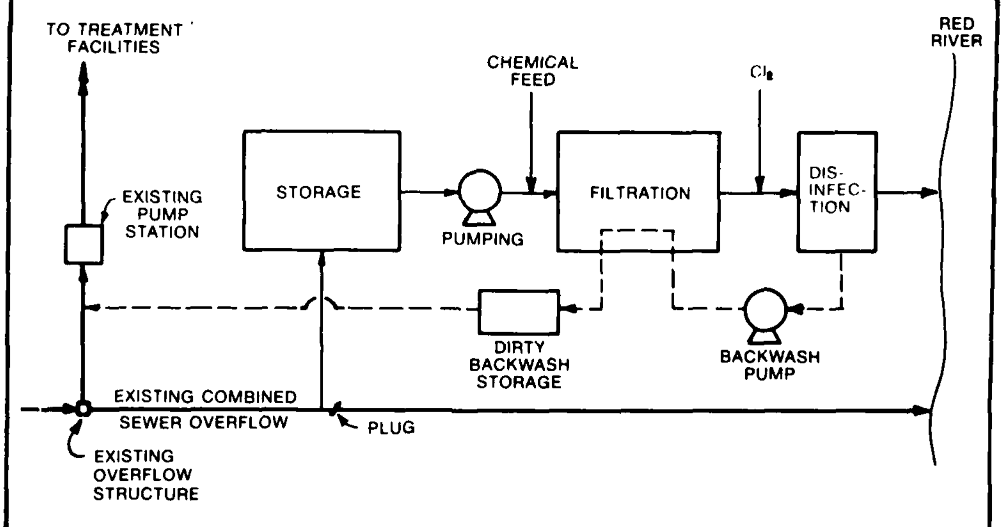

Figure 10 - High Rate Filtration Schematic

During storms the combined sewer overflows would flow by gravity into underground concrete storage basins. The storage basins would provide two functions. They would serve as sedimentation facilities to remove the heavier solids and they would also act as equalization basins to reduce peak flow rates on the remaining treatment processes. The storage facilities have been sized to hold the entire runoff volume from a 1 -year, 2 -hour storm. The storage volume required for each service area can be obtained from table 4 which was presented earlier in this report. Larger storms would cause some combined sewer overflow to be discharged directly to the Red River of the North. The pumping, filtration, and disinfection facilities have been sized such that the storage basin can be emptied in a period of 24 hours following the 1 -year, 2 -hour design storm. After all of the water is pumped from the basins, the sludge would be removed and the facilities would be ready for the next storm.

High rate filtration treatment was considered for two alternative applications:

- Alternative 5 - Filtration Treatment by Service Area: Collect overflows at individual service area sites and treat individually by high rate filtration.
- Alternative 6 - Regionalized Filtration Treatment: Collect all overflows at one site and treat by high rate filtration.

Figure 11 shows the location of a proposed regional treatment site, and figure 12 shows individual service area sites.

Alternatives 7 and 8 - Sedimentation Treatment

The objective of sedimentation treatment is similar to that of high rate filtration treatment. This alternative is identical to the filtration alternative except for the use of the filtration process and associated facilities. Combined sewer overflows would flow by gravity into the equalization/storage facilities.

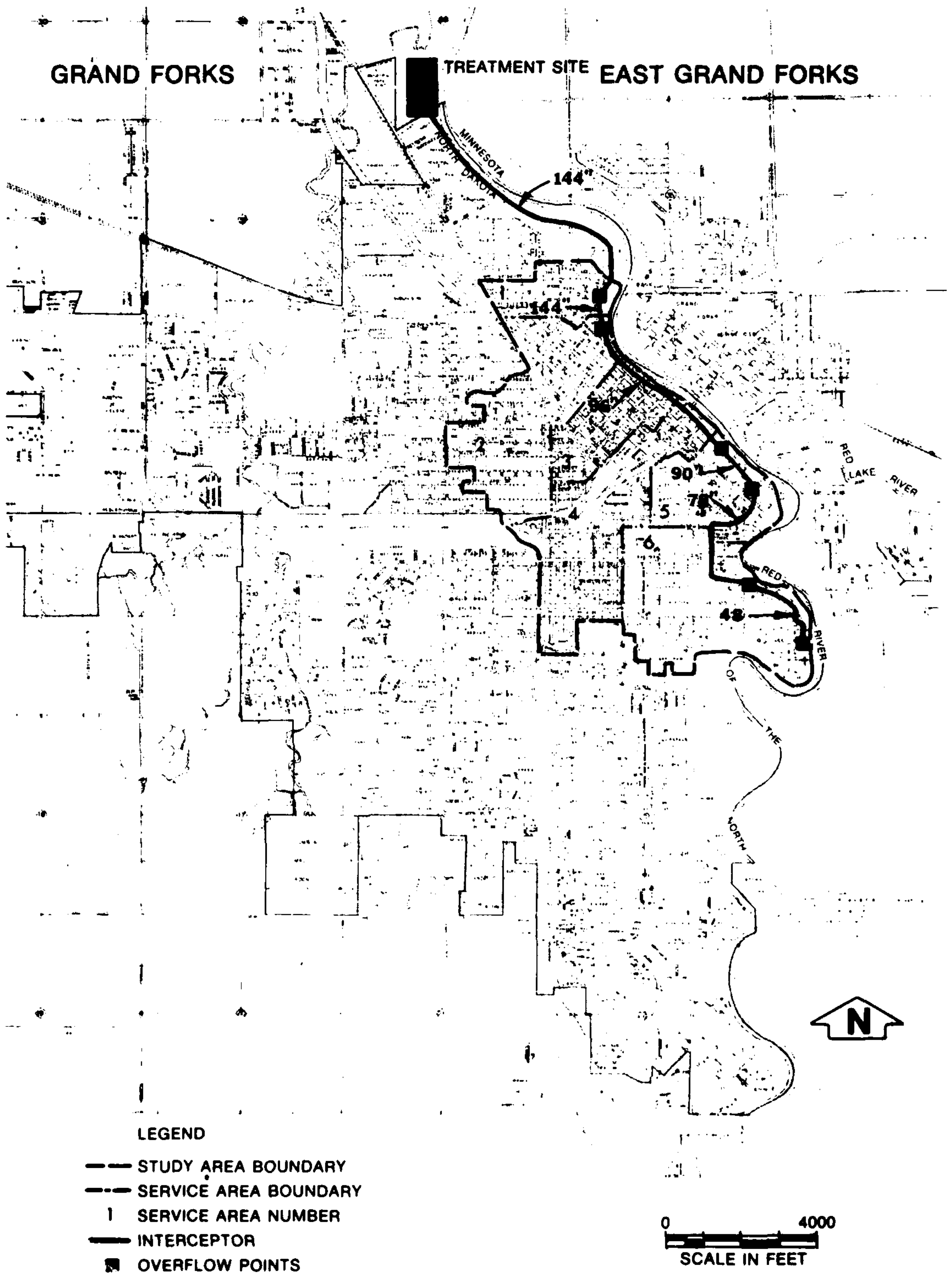

Figure 11 - Alternatives 6 and 8
Storage and Treatment — Single Site

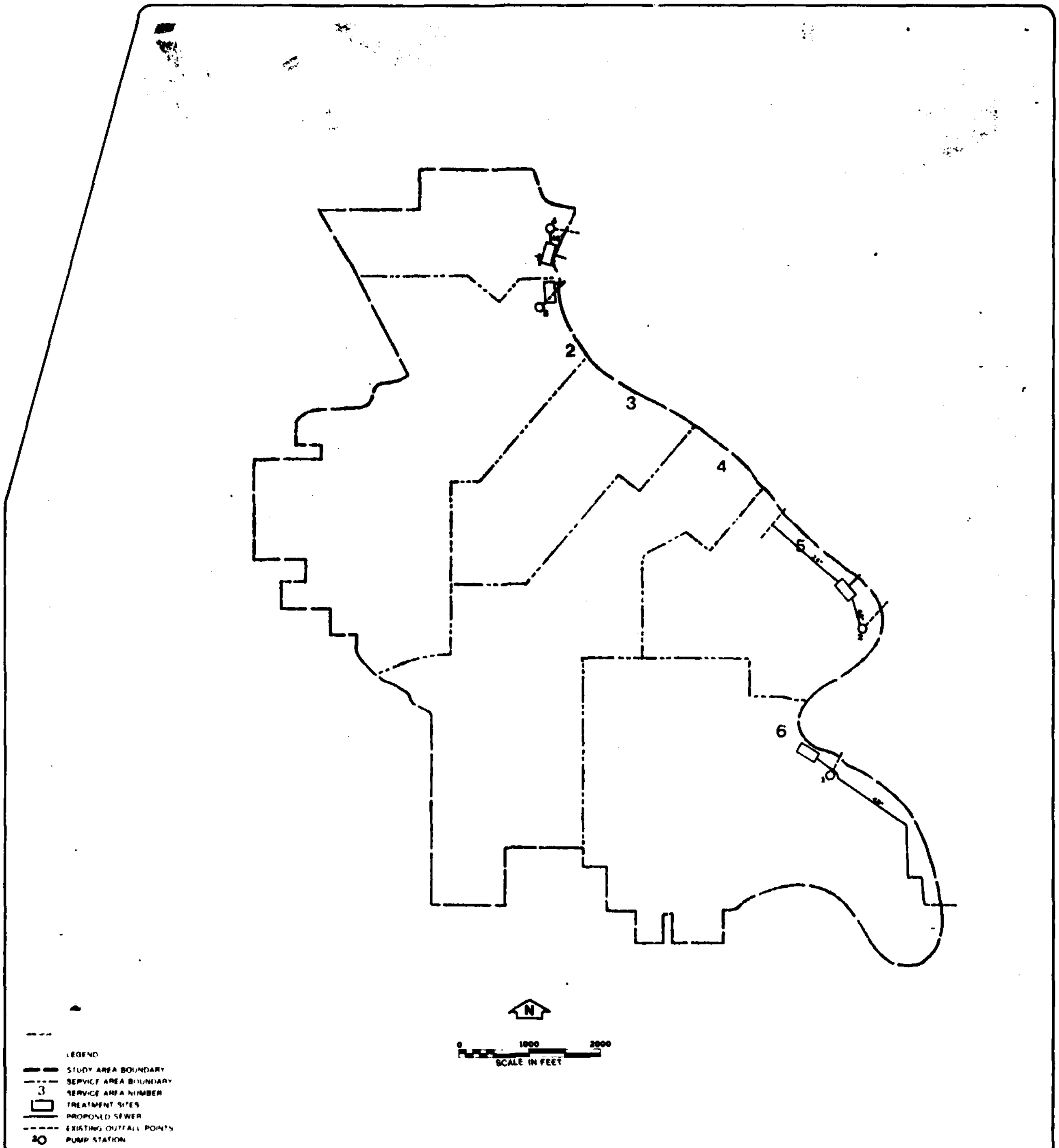

Figure 12 - Alternatives 5, 7 and 9 Treatment at Individual Service Areas

The storage basins would also provide sedimentation. Flow would be pumped from the storage basins through chlorination facilities before discharge to the Red River. Figure 13 shows a sedimentation treatment schematic.

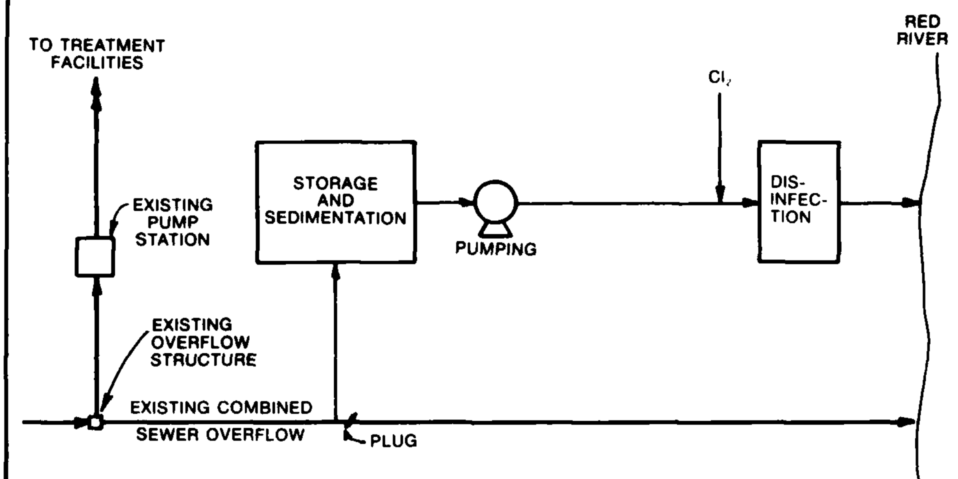

Figure 13 - Sedimentation Schematic

Sedimentation treatment was considered in two respects as alternatives:

- Alternative 7 - Sedimentation Treatment by Service Area: Collect overflows at individual service area sites and treat individually by sedimentation.
- Alternative 8 - Regionalized Sedimentation Treatment: Collect all overflows at one site and treat by sedimentation.

Individual service area treatment sites are shown on figure 12, and a regional site plan is shown on figure 11.

SWIRL CONCENTRATOR TREATMENT ALTERNATIVE

ALTERNATIVE 9

Swirl concentrators can be used to remove many of the pollutants from the combined sewer overflows before

discharge to the Red River. The application of swirl concentrators to treat combined sewer overflows has received much attention during the past 8 years. The U.S. EPA has sponsored several research and demonstration projects and has issued several publications on swirl concentrators. Several references (14, 15, 16, 17, 18, 19) were used during the development and sizing of the swirl concentrator alternative. In addition, discussions were held with personnel from EPA's Storm and Combined Sewer Section of the Municipal Environmental Research Laboratory confirming design criteria used for the swirl concentrator alternative.

Swirl concentrators are sized to treat peak flow rates since storage or equalization facilities would add substantially to the costs and would also remove many of the heavier solids which the swirl concentrators are designed to remove. If site conditions and hydraulic conditions permit, no influent pumping is required and discharge from the combined sewer through the swirl concentrator to the receiving stream is by gravity. However, at Grand Forks site conditions and flooding conditions are such that influent pumping will be required. Two problems would be encountered if swirl concentrators were installed without pumping.

First, basement backups and street flooding with combined sewage are a problem because of the flat topography and inadequate storm carrying capacity of the existing combined system. Head losses caused by the swirl concentrators would be imposed on the existing combined sewer system and would increase street flooding and basement backup problems. Head losses associated with swirl concentrators consist of pipe losses caused by fittings and reduced pipe sizes and inlet, outlet, and weir losses in the concentrators. The total head loss varies with the amount of flow through the units but exceeds 3 feet at design flow conditions. The maximum head loss through the swirl concentrators would coincide with peak flow rates in the sewer collection

system and the additional basement backups would be unacceptable to people living in the combined sewer area.

The second problem which would be encountered if pumping were not used consists of not being able to operate the facilities when the river rises more than a few feet above the normal pool elevation. An EPA technical bulletin (20) specifies that treatment facilities shall remain fully operational during the 25-year flood, if practicable. Lesser flood levels may be permitted in some cases, but in no case shall less than a 10-year flood be used.

Figure 6, which was presented earlier in this report, shows a profile and the relative elevations of the combined sewer overflow pipe for Service Area 2. Overflow pipes for each of the other service areas are similar to Area 2. Approximate elevations for various frequency floods are also shown on figure 6. The existing combined sewers are approximately 20 feet deep as they approach the existing pump stations. After an overflow structure diverts dry weather flows to the pump stations, the combined sewer overflow pipes slope downward to discharge at or below the normal pool level in the Red River. The invert elevations of the existing combined sewer overflow pipes are listed in table 11.

Table 11 - Combined sewer overflow invert elevations

Service Area	Invert Elevation (ft above mean sea level) Combined Sewer Near Pump Station	Outfall Into Red River
1	808.3	Below normal pool[1]
2	809.5	Below normal pool[1]
5	808.0	Below normal pool[1]
6	800.0	793.1

[1]Normal pool elevation of 793 is maintained by low head dam.

Source: Stanley Consultants and City of Grand Forks

The 25-year flood elevation in the Red River is approximately 824 and the 10-year flood elevation is approximately 821 at the combined sewer overflow discharges. The 1-year flood elevation is 816 and there would be several occurrences each year when the swirl concentrators would be flooded and inoperable.

Figure 14 presents a schematic of the proposed swirl concentrator treatment facilities. One treatment facility would be located in each service area approximately as shown on figure 12.

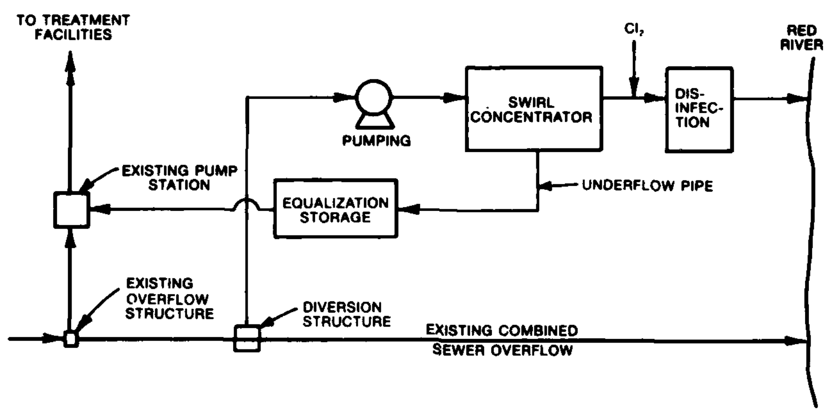

Figure 14 - Swirl Concentrator Schematic

Since the treatment facilities must be sized for peak flow rates, the sizing of the units and the associated costs are heavily influenced by the selected design storm. After evaluation of a 1-year, 0.5-year, and 0.25-year design storm, the 0.25-year design storm was selected. Combined sewer overflows would exceed the capacity of the facilities approximately four times per year resulting in some untreated discharges to the Red River.

However, approximately 93 percent of the total annual volume of combined sewer overflow would be treated each year using the 0.25-year storm. Peak flow rates for this design storm range from 33 cfs for Service Area 1 to 105 cfs for Service Area 6.

The proposed pumping facilities are sized to pump the peak flow rate for the 0.25-year design storm. Swirl concentrators are capable of operating over a wide flow range and are normally designed for a peak hydraulic loading 100 percent greater than the design flow rate. For this study the design flow rate for the swirl concentrators has been selected to equal one half of the 0.25-year storm peak flow rate. The peak hydraulic capacity of the swirl concentrators will equal the pumping capacity which corresponds to the 0.25-year design storm. One swirl concentrator will be used at each treatment location. Chlorination facilities are sized for the 0.25-year design storm.

The solids which are concentrated in the swirl concentrator will be removed along with between 3 and 10 percent of the inflow liquid volume through an underflow pipe. This flow greatly exceeds the capacity of the existing pump stations and must be stored. After the storm is over, the underflow will be slowly drained into the existing pump station where it will be pumped to the wastewater treatment plant.

OTHER ALTERNATIVES

Relocate Water Intakes

One of the major concerns of combined sewer overflows is their adverse impact on receiving water quality. And because the receiving water is the water source for Grand Forks, adverse health effects could result. Intakes for the city water supply are indicated on figure 15, as is the dam forming the pool at Grand Forks. Because of the very gentle slope of the river, the pool formed by the dam extends several miles upstream of the dam. Because of the long raw-water line

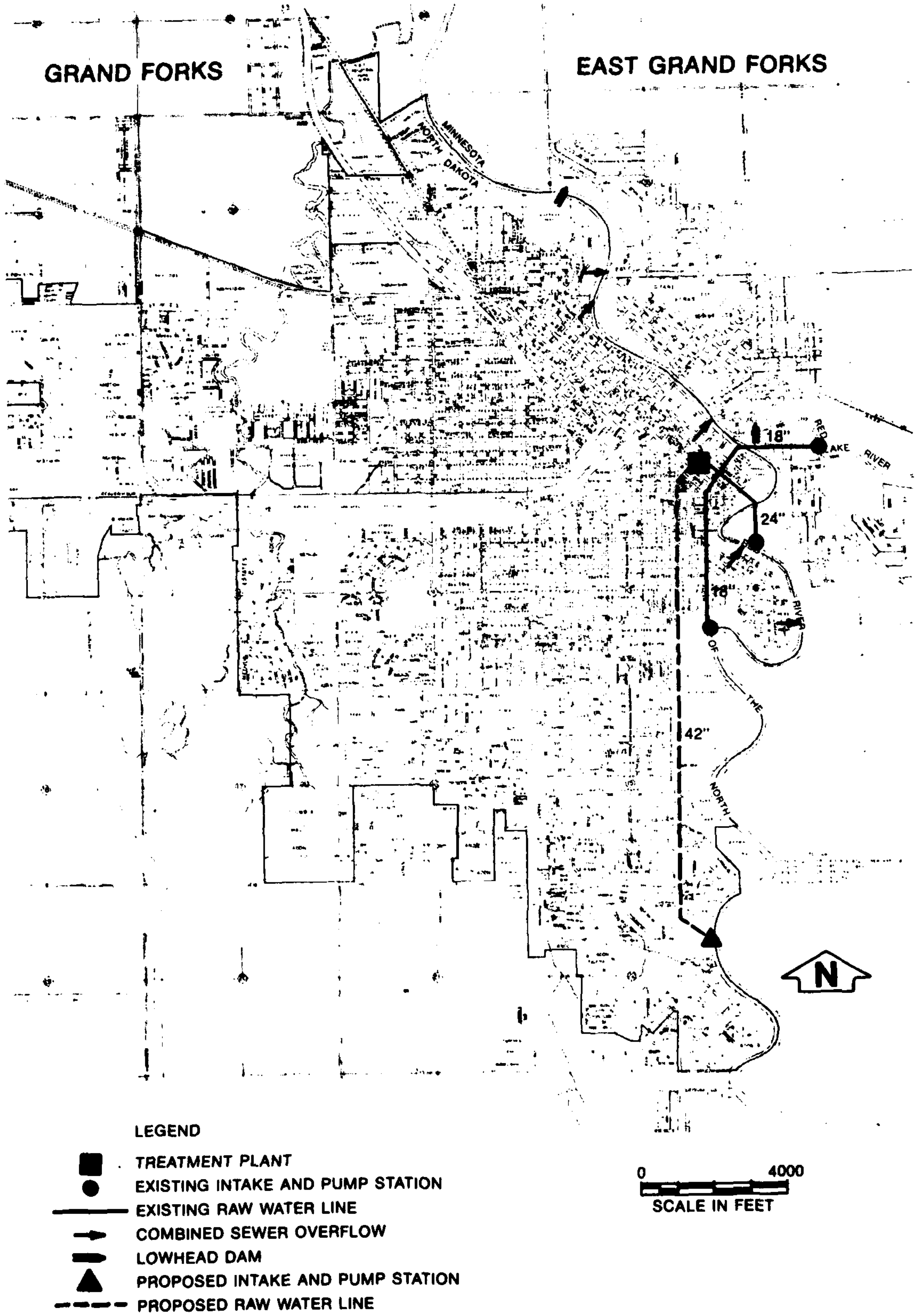

Figure 15 - Relocate Water Intake

involved, it would not be feasible to locate a new intake outside of the pool area. Intakes located in the pool area result in stagnant, poor quality water during low-flow periods; but a pool is desirable to maintain an adequate water source during dry periods.

The alternative developed here proposes replacing the existing intakes with one intake located approximately 2 miles upstream of any combined sewer overflows. Staying within the pool area will provide for a reliable water source, but locating intakes a distance upstream of overflow points would minimize any adverse health effects caused by the combined sewer overflows. The proposed location is also upstream of a majority of the developed urban area and will minimize the impact of urban nonpoint runoff. Because this alternative does not attack the problem, but rather its effects, it cannot be considered in the same light as the other alternatives.

No Action Plan

The no action plan would allow the continued discharge of combined sewer overflows into the Red River of the North. Since the combined sewer area of Grand Forks is fully developed, the waste load to the river with the no action plan is expected to remain about the same as it is now. The no action plan would not limit development in the combined sewer area since it is already developed. There are no capital expenditures associated with the no action plan. However, Grand Forks would still be in violation of its current discharge permit and the combined sewer overflows would continue to be a source of pollutants and potential public health problems.

Collection System and Source Management

Collection system and source management are being considered in conjunction with other formulated alternatives because of their limited impact if implemented alone. They are easily implemented and could complement any proposed plan.

Source management includes street cleaning, sewer flushing and catch basin cleaning. Sewer flushing and catch basin cleaning have a relatively low capital cost but high operational costs. Sewer flushing and catch basin cleaning remove debris and sediment to achieve full capacity of the system. To be effective, a regular cleaning program should be established for storm and sanitary sewers. A regular street cleaning program can remove potential pollutants from the street, but the reduction is somewhat less than 50 percent of the pollutants contained on the street.(11) Street cleaning also has a low capital cost, but high operational cost.

Collection system management involves any management possible through the use of control structures. Overflow structures are generally a potential means of control; but, because the existing structures are simply an overflow weir placed in-line, variable control is not possible. A second possible means of control is pump stations; but, because the capacity of the pump stations is so limited, little control is possible.

Collection system and source management will be evaluated in terms of the quantity of pollutant reduction achieved and the additional impact relative to other alternatives.

IMPACT ASSESSMENT AND EVALUATION

DISCUSSION OF ALTERNATIVES

This section presents the developed alternatives and discusses their economic impact. In PART VI, alternatives were presented on a study area basis, whereas selection will be made for each service area individually to develop the most cost-effective overall plan.

Cost Estimating Methodology

Estimates have been developed for construction costs, operation and maintenance costs, and salvage values for each alternative. Cost estimates are based on May 1979 prices in the Grand Forks area. The construction cost estimates for sewer systems were developed by Stanley Consultants and are based on manufacturer information and recent bid experience on similar construction in Grand Forks. Construction cost estimates for treatment facilities are based on cost curves and published unit cost data. The cost of construction will be somewhat higher than the estimates contained in this report as a result of inflation between May 1979 and the actual time of construction.

Construction costs include such items as excavation, concrete, pipe, purchase and installation of mechanical equipment, electrical work, contractors' overhead and profit, and other related costs. An allowance of 20 percent is provided for contingencies, engineering, legal, and administrative costs to establish the total estimated project costs for each alternative.

Operation and maintenance costs include expenditures for administering and operating the facilities and the costs of

providing routine maintenance and minor repair. These costs include labor, electrical power, chemicals, and other required materials.

The economic analysis is based upon a 20-year planning period as required by U.S. EPA. A salvage value has been estimated assuming that at the end of the 20-year planning period the structures can continue to fulfill their planned purpose. The salvage value is based upon a straight line depreciation over the assumed service life of the structure. The salvage value is based upon May 1979 prices. The average life of sewers, storage basins, and major structures is considered to be 50 years. Therefore, the salvage value is estimated to be 60 percent of the original cost. The salvage value of land is assumed to be 100 percent at the end of 20 years. Major mechanical equipment such as pumps, aerators, and chlorination equipment was assumed to have a life of 20 years which corresponds to the design period of the project; therefore, the mechanical equipment has no salvage value. Facilities such as pump stations which contain both major structures and mechanical equipment have a salvage value of 60 percent for the structural portion and 0 for the equipment portion.

If the economic analysis had been based on the 50-year planning period used for the urban study, the equivalent annual cost and the relative ranking of each alternative would remain unchanged. Since the study area is completely developed, the proposed facilities for each alternative would be sized the same for a 50-year planning period as they are for a 20-year planning period. Initial construction costs and annual operation and maintenance costs would remain unchanged. With a 50-year planning period facilities such as sewers, storage basins, and major structures would have no salvage value since their useful life is considered to be 50 years. Major mechanical

equipment and other items with a 20-year life would have to be replaced at the end of 20 years and 40 years and would have a salvage value of 50 percent of the original cost at the end of the 50-year planning period. When all of these costs are converted to an annual basis, the equivalent annual cost of each alternative will be the same for a 50-year planning period as for the 20-year planning period.

Alternative 1 - New Sanitary Sewer System

Construction of a new sanitary sewer system and conversion of the existing combined sewers to a storm sewer system will significantly reduce the pollution load to the Red River by eliminating the discharge of sanitary wastes. It is possible to calculate the reduced pollution load using typical BOD, total suspended solids (TSS), and fecal coliform values shown in table 7. The average BOD concentration is 115 mg/l for combined sewers and 20 mg/l for storm sewers. This indicates that the BOD of the pollutants discharged to the river at the overflow points will be reduced approximately 83 percent by separating the sewers. The pollutants no longer discharged by the overflows will go to the existing wastewater treatment plant where the BOD removal efficiency is approximately 95 percent. The 5 percent not removed will be discharged with the final wastewater treatment effluent into the Red River downstream from Grand Forks. This results in a net BOD removal of approximately 80 percent. Total suspended solids may not be reduced by sewer separation and, in fact, may be increased slightly. Many of the heavier solids associated with the storm runoff, which are currently diverted by the overflow structures to the wastewater treatment plant, would be confined to the storm sewer system and go directly to the river. However, the organic solids associated with sanitary wastes will no longer be discharged

to the river. The fecal coliforms discharged to the river will be reduced by 95 to 100 percent.

By constructing a new sanitary sewer system and retaining the existing combined sewers for storm sewer service, there will be no change in the degree of surface flooding in the study area. Basement backups will be eliminated because house services will no longer be connected to storm drainage. Construction of new sanitary sewers will minimize infiltration and inflow in the collection system. However, it is anticipated that fairly high rates of infiltration and inflow may be attributed to service connections.

The new sanitary sewer will generally be constructed parallel to and deeper than the existing combined sewer. Sanitary sewer connections which are now joined to the combined sewer system will be rerouted to the new sanitary sewer as shown on figure 16.

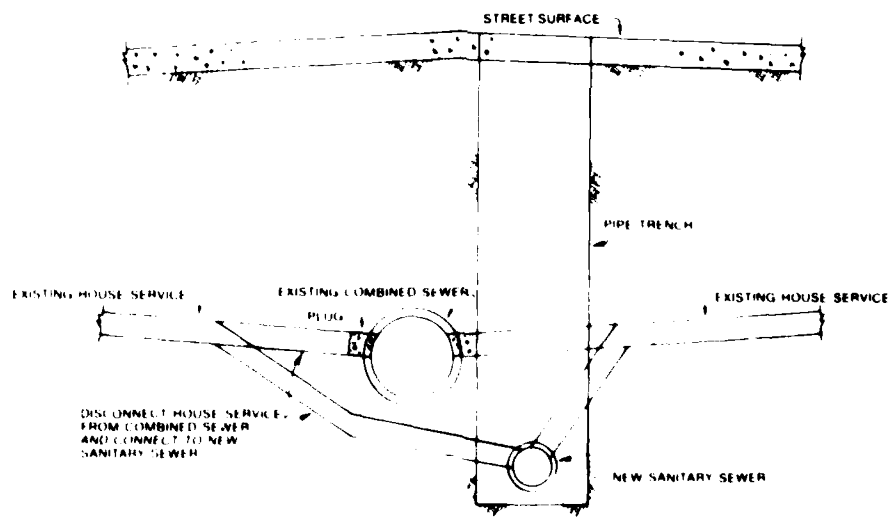

Figure 16 - Sanitary Service Connection Detail

In several parts of the study area the existing combined sewers are constructed in alleys. In some of these alleys it may be very difficult to construct the new sanitary sewers paralleling the combined sewers because of limiting working conditions and possible conflicts with other utilities. In many cases, garages are located close to the alley right-of-way and power poles are located in the alley. In some of these areas it may be necessary to construct new storm sewers in the streets rather than new sanitary sewers in the alleys.

The new sanitary sewers will be connected to the existing pump station wet wells. The new sanitary sewers will be constructed at a deeper depth than the existing combined sewers. The bottom elevations of the existing pump stations appear to be several feet below the invert elevations of the existing combined sewers, therefore it is anticipated that the new sanitary sewers can be connected to the pump stations without major modifications.

The major construction cost item for this alternative is pipe installation and material. Other costs will be incurred to modify and convert the existing system to a storm sewer. After new sanitary sewers are constructed, a smoke test of the system will be necessary to locate sources of inflow in the house services, such as downspout connections and area drains. Table 12 shows the cost estimate for a new sanitary sewer system and conversion of the existing combined system to a storm sewer system. Table 13 presents a breakdown of the sanitary sewer costs and pipe sizes for each service area.

Operation and maintenance costs for this alternative include routine cleaning of the storm and sanitary systems. It was assumed that the sanitary system will be cleaned on a 10-year cycle such that one tenth of the system will be cleaned each

Table 12 - Cost estimate[1] for alternative 1 - new sanitary sewer system

	Service Area 1		Service Area 2		Service Area 5		Service Area 6	
	Construction Cost ($1,000)	Salvage Value ($1,000)	Construction Cost ($1,000)	Salvage Value ($1,000)	Construction Cost ($1,000)	Salvage Value ($1,000)	Construction Cost ($1,000)	Salvage Value ($1,000)
Sanitary Sewers	[illegible]	[illegible]	3,640	2,184	1,424	854	3,157	1,894
Manholes	74	44	240	144	68	41	216	130
Modifications to Existing System	25	12	80	37	34	16	72	33
Smoke Testing New Sanitary System	2	--	7	--	3	--	6	--
Undeveloped Design Detail Cost (15%)	177	105	595	355	229	137	518	309
Total Estimated Construction Cost	1,354	--	4,562	--	1,758	--	3,969	--
Contingencies, Engineering, Legal and Administrative (20%)	271	--	912	--	352	--	794	--
Total Estimated Project Cost	1,625	807	5,474	2,720	2,110	1,048	4,763	2,366
Operation and Maintenance Cost ($/yr)								
New Sanitary Sewer System	$1,620/yr		$5,740/yr		$2,090/yr		$4,490/yr	
Existing Combined Used for Storm Sewer	1,120/yr		3,440/yr		1,020/yr		2,060/yr	
Total	$2,740/yr		$9,180/yr		$3,110/yr		$6,550/yr	

[1] Based on May 1979 costs.

Source: Stanley Consultants

Table 13 - Sewer cost[1] for alternative 1 - new sanitary sewer system

Pipe Size (in.)	Unit Cost ($/ft)	Service Area 1		Service Area 2		Service Area 5		Service Area 6	
		Length (ft)	Cost ($)	Length (ft)	Cost ($)	Length (ft)	Cost ($)	Length (ft)	Cost ($)
8	78	13,200	1,029,600	37,300	2,909,400	17,800	1,388,400	37,000	2,886,000
10	88	--	--	1,200	105,600	400	35,200	500	44,000
12	92	500	46,000	3,600	331,200	--	--	900	82,800
15	96	--	--	2,000	192,000	--	--	1,500	144,000
18	102	--	--	1,000	102,000	--	--	--	--
Total		13,700	1,075,600	45,100	3,640,200	18,200	1,423,600	39,900	3,156,800

[1] Based on May 1979 costs.

Source: Stanley Consultants

year. It was assumed that the storm system will be cleaned on a 40-year cycle.

Alternative 2 - New Storm Sewer System

Alternative 2 consists of constructing a new storm sewer system and retaining the existing combined sewers as a sanitary sewer system. Construction of a new storm sewer system sized for a 10-year storm will greatly reduce surface flooding problems and eliminate basement backups in the study area. By separating the sewers, quantities of BOD, TSS, and fecal coliform discharged to the river will experience the same changes as for alternative 1. Of significance is the 80 percent reduction in BOD. Storm runoff will be discharged directly to the Red River of the North, while sanitary flows will be collected in the existing main interceptor and taken to the wastewater treatment plant.

Pipe installation and material is the most significant cost of this alternative. The existing combined sewer system will require a sewer system evaluation survey after it is converted to a sanitary sewer system, and subsequent rehabilitation must be performed as indicated by the survey. The survey and rehabilitation will reduce infiltration and inflow into the system. The cost estimate for this alternative is shown in table 14. The total length of each size sewer and the cost breakdown for the proposed storm sewer system are shown in table 15.

Operation and maintenance costs for a new storm sewer system and use of the existing combined system for sanitary sewer service consist mainly of sewer cleaning. It was assumed that storm sewers will be cleaned on a 40-year cycle and sanitary sewers will be cleaned on a 10-year cycle.

Alternative 3 - New Sanitary and New Storm Systems - Utilizing Existing

Alternative 3 uses portions of the existing combined sewer system for sanitary service and other portions for storm

Table 14 - Cost estimate[1] for alternative 2 - new storm sewer system

	Service Area 1		Service Area 2		Service Area 5		Service Area 6	
	Construction Cost ($1,000)	Salvage Value ($1,000)	Construction Cost ($1,000)	Salvage Value ($1,000)	Construction Cost ($1,000)	Salvage Value ($1,000)	Construction Cost ($1,000)	Salvage Value ($1,000)
Storm Sewers	857	514	34,648	2,189	990	594	3,111	1,867
Manholes	50	30	230	138	61	37	206	124
Catch Basins	12	7	55	33	22	13	43	26
Head Walls	4	2	9	5	7	4	8	5
Connecting in Catch Basins	66	40	312	187	126	76	243	146
Undeveloped Design Detail Cost (15%)	148	89	638	383	181	109	542	325
Total Estimated Construction Cost	1,137	--	4,992	--	1,387	--	4,153	--
Contingencies, Engineering, Legal and Administrative (20%)	227	--	978	--	277	--	831	--
Sewer System Evaluation Survey and Rehabilitation[2]	380	169	1,266	562	380	169	1,139	506
Total Estimated Project Cost	1,744	851	7,136	3,497	2,044	1,002	6,123	2,999
Operation and Maintenance Cost ($/yr)								
Combined Converted to Sanitary System	$4,480/yr		$13,760/yr		$4,070/yr		$8,230/yr	
New Storm Sewer System	990/yr		3,720/yr		1,210/yr		3,440/yr	
Total	$5,470/yr		$17,480/yr		$5,280/yr		$11,670/yr	

[1]Based on May 1979 costs.
[2]To retain existing system as sanitary.

Source: Stanley Consultants

Table 15 - Sewer cost[1] for

alternative 2 - new storm sewer system

Pipe Size (in.)	Unit Cost ($/ft)	Service Area 1 Length (ft)	Service Area 1 Cost ($)	Service Area 2 Length (ft)	Service Area 2 Cost ($)	Service Area 5 Length (ft)	Service Area 5 Cost ($)	Service Area 6 Length (ft)	Service Area 6 Cost ($)
15	56	370	20,720	3,170	177,520	740	41,440	1,910	106,960
18	58	3,330	193,140	5,050	292,900	880	51,040	5,860	339,880
21	61	2,600	158,600	3,570	217,770	1,210	73,810	5,910	360,510
24	64	710	45,440	4,270	273,280	2,830	181,120	--	--
27	102	--	--	4,500	459,000	--	--	3,970	404,940
30	109	370	40,330	3,990	434,910	1,010	110,090	3,090	336,810
33	119	--	--	1,180	140,420	240	28,560	780	92,820
36	139	380	52,820	570	79,230	1,190	165,410	3,020	419,780
42	153	460	70,380	740	113,220	710	108,630	3,030	463,590
48	170	480	81,600	790	134,300	1,350	229,500	370	62,900
54	178	1,090	194,020	1,290	229,620	--	--	530	94,340
60	208	--	--	720	149,760	--	--	530	110,240
66	232	--	--	350	81,200	--	--	1,370	317,840
72	267	--	--	380	101,460	--	--	--	--
78	289	--	--	2,640	762,960	--	--	--	--
Total		9,790	857,050	33,210	3,647,550	10,160	989,600	30,370	3,110,610

[1]Based on May 1979 costs.

Source: Stanley Consultants

sewer service. New sections of sanitary and storm sewer are required to complete each system. The advantages of this alternative are similar to the advantages of a new storm sewer system (alternative 2). The approach taken in developing this alternative was to identify particular areas with inadequate storm drainage capacity. By constructing new storm lines for inadequate sections, the stormwater runoff carrying capacity of the system can be increased, while as much of the existing system as possible can be used for the storm sewer system. Levels of protection possible by alternative 3 are shown in table 10. Surface flooding in the area will be reduced and the health hazard of sanitary wastes in storm sewer overflows and basement flooding would be eliminated.

Reductions of pollutant loadings to the Red River are the same as for the other sewer separation alternatives. A significant reduction of about 80 percent is anticipated for BOD.

Where new sanitary sewers are constructed, service connections will be rerouted to the new sewers as described for alternative 1. New sanitary lines will, for the most part, be run parallel to and deeper than existing combined sewer lines to facilitate the rerouting of the service connections.

New sewer installation and material costs make up a majority of the cost for alternative 3. Smoke testing of the sanitary sewer will be necessary to detect points of inflow in the house service lines. Rehabilitation of the existing combined system may be necessary in areas where it is used as a sanitary sewer. The cost estimate for this alternative is shown in table 16. Table 17 presents the sewer sizes and costs for this alternative.

Operation and maintenance costs for the sanitary and storm sewers consist of the cost of sewer cleaning. It was assumed

Table 16 - Cost estimate[1] for alternative 3 - new sanitary and new storm systems - utilizing existing

	Service Area 1		Service Area 2		Service Area 5		Service Area 6	
	Construction Cost ($1,000)	Salvage Value ($1,000)	Construction Cost ($1,000)	Salvage Value ($1,000)	Construction Cost ($1,000)	Salvage Value ($1,000)	Construction Cost ($1,000)	Salvage Value ($1,000)
Sewers	1,076	646	4,009	2,405	1,662	997	5,015	3,009
Manholes	74	44	256	154	76	46	224	134
Catch Basins			55	33	22	13	43	26
Head Walls	--	--	4	2	4	2	--	--
Connecting in Catch Basins	--	--	--	--	--	--	122	73
Misc. Costs for Modifications	25	12	80	37	34	16	36	16
Smoke Testing New Sanitary System	2	--	8	--	4	--	7	--
Undeveloped Design Detail Cost (15%)	177	105	662	395	270	161	817	489
Total Estimated Construction Cost	1,354	--	5,074	--	2,072	--	6,264	--
Contingencies, Engineering, Legal, and Administrative (20%)	271	--	1,015	--	414	--	1,253	--
Sewer System Evaluation Survey and Rehabilitation[2]	--	--	--	--	--	--	570	253
Total Estimated Project Cost	1,625	807	6,089	3,026	2,486	1,235	8,087	4,000
Operation and Maintenance Cost ($/yr)								
Sanitary Sewer System	$1,620/yr		$5,740/yr		$2,090/yr		$6,360/yr	
Storm Sewer System	1,120/yr		3,440/yr		$1,020/yr		2,750/yr	
Total	$2,740/yr		$9,180/yr		$3,110/yr		$9,110/yr	

[1]Based on May 1979 costs.

[2]To retain existing system as sanitary.

Source: Stanley Consultants

Table 17 - Sewer cost[1] for
alternative 3 -
new sanitary and new storm systems - utilizing existing

Pipe Size (in.)	Unit Cost ($/ft)	Service Area 1 Length (ft)	Service Area 1 Cost ($)	Service Area 2 Length (ft)	Service Area 2 Cost ($)	Service Area 5 Length (ft)	Service Area 5 Cost ($)	Service Area 6 Length (ft)	Service Area 6 Cost ($)
Sanitary Sewers									
8	78	13,200	1,029,600	37,300	2,909,400	16,950	1,321,300	35,190	2,744,820
10	88	--	--	1,200	105,600	--	--	500	44,000
12	92	500	46,000	3,600	331,200	--	--	900	82,800
15	96	--	--	2,000	192,000	--	--	1,500	144,000
18	102	--	--	1,000	102,000	--	--	--	--
Subtotal		13,700	1,075,600	45,100	3,640,200	16,950	1,321,300	38,090	3,015,620
Storm Sewers									
18	58	--	--	--	--	--	--	5,100	295,800
21	61	--	--	--	--	--	--	3,900	237,900
24	64	--	--	200	12,800	--	--	2,100	134,400
27	102	--	--	--	--	--	--	1,700	173,400
30	109	--	--	--	--	--	--	1,800	196,200
33	119	--	--	--	--	--	--	350	41,650
36	139	--	--	200	27,800	700	97,300	800	111,200
42	153	--	--	200	30,600	--	--	100	15,300
48	170	--	--	600	102,000	700	119,000	--	--
54	178	--	--	1,100	195,800	700	124,600	500	89,000
72	267	--	--	--	--	--	--	1,100	293,700
84	342	--	--	--	--	--	--	1,200	410,400
Subtotal		--	--	2,300	369,000	2,100	340,900	18,650	1,998,950
TOTAL		13,700	1,075,600	47,400	4,009,200	19,050	1,662,200	56,740	5,014,570

[1] Based on May 1979 costs.

Source: Stanley Consultants

that sanitary sewers will be cleaned on a 10-year cycle and storm sewers on a 40-year cycle.

Alternative 4 - New Sanitary and New Storm Systems-Abandoning Existing

Alternative 4 is simply a combination of alternatives 1 and 2. This involves constructing new sanitary and new storm sewer systems and abandoning the existing combined system entirely. The benefits of this are the same as those for alternatives 1 and 2. Pollutant quantities discharged to the receiving water can significantly be reduced and the level of flood protection in the service area can be maximized. The design storm used in sizing a new storm sewer system was a 10-year storm.

The costs of this alternative are shown in table 18 and consist primarily of piping material and installation. Existing house services would be used; therefore, smoke testing would be necessary to identify points of inflow in these services. Operation and maintenance requirements are similar to those of the other separation alternatives.

The main disadvantage of this alternative is that the existing system is abandoned. There is potential use left in the existing system, and totally abandoning it results in higher construction costs for sewer service in the study area.

Alternative 5 - Filtration Treatment by Service Area

Alternative 5 consists of providing temporary storage and treatment of combined sewer overflows prior to discharge into the Red River. Separate facilities would be constructed in each service area and located as near the existing overflow points as possible. Suitable land available for the construction of treatment facilities is extremely limited and at most locations it will be necessary to locate facilities on existing parkland or remove some houses or other buildings.

Table 18 - Cost estimate[1] for alternative 4 - new sanitary and new storm system - abandoning existing

	Service Area 1		Service Area 2		Service Area 5		Service Area 6	
	Construction Cost ($1,000)	Salvage Value ($1,000)	Construction Cost ($1,000)	Salvage Value ($1,000)	Construction Cost ($1,000)	Salvage Value ($1,000)	Construction Cost ($1,000)	Salvage Value ($1,000)
Sewers	1,933	1,160	7,288	4,373	2,414	1,448	6,268	3,761
Manholes	124	74	470	282	129	78	422	254
Catch Basins	12	7	55	33	22	13	43	26
Head Walls	4	2	9	5	7	4	8	5
Connecting in Catch Basins	66	40	312	187	126	76	243	146
Smoke Testing Sanitary System	2	--	7	--	3	--	6	--
Undeveloped Design Detail Cost (15%)	321	192	1,221	732	405	243	1,049	629
Total Estimated Construction Cost	2,462	--	9,362	--	3,106	--	8,039	--
Contingencies, Engineering, Legal, and Administrative (20%)	492	--	1,872	--	621	--	1,608	--
Total Estimated Project Cost	2,954	1,475	11,234	5,612	3,727	1,862	9,647	4,821
Operation and Maintenance Cost ($/yr)								
New Sanitary Sewer System	$1,620/yr		$5,740/yr		$2,090/yr		$4,490/yr	
New Storm Sewer System	990/yr		3,720/yr		1,210/yr		3,440/yr	
Total	$2,610/yr		$9,460/yr		$3,300/yr		$7,930/yr	

[1] Based on May 1979 costs.

Source: Stanley Consultants

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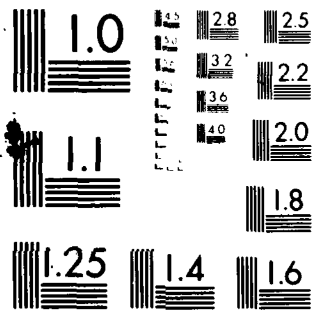

MICROCOPY RESOLUTION TEST CHART

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During storms, combined wastewater will flow by gravity into underground concrete storage tanks. The storage tanks will provide flow equalization and sedimentation. The wastewater will be pumped from the storage tanks through high rate filtration and chlorination facilities prior to discharge into the Red River. To minimize costs and land requirements, the storage basins were sized to hold the runoff from a 1-year storm with portions of the flow from larger storms discharged directly to the river. Table 19 presents construction and operation and maintenance costs for this alternative.

It is estimated that if properly operated the treatment facilities will remove 90 to 95 percent of the suspended solids and 75 to 85 percent of the BOD in the wastewater. Chlorination will reduce the coliform count to near zero.

Since the facilities would only be operated for relatively short periods of time following storms, it is anticipated that they would be difficult for Grand Forks to manage. Skilled operators would have to be available on short notice to operate the facilities following a storm. Storage basins would also have to be cleaned after each storm and the sludge properly disposed of.

Alternative 6 - Regionalized Filtration Treatment

This alternative uses the same treatment processes as alternative 5 except that all of the combined wastewater is taken to a single site for storage and treatment. A massive collection system of 48-inch through 144-inch pipe is required to collect the combined wastewater and convey it to the treatment site north of the city. The sewer is designed for gravity flow and approaches a depth of 50 feet at the treatment site. A cost estimate for this alternative is shown in table 20. As shown in the cost estimate, the collection system accounts for approximately 80 percent of the cost of this alternative.

Table 19 - Cost estimate[1] for alternative 5 - filtration treatment by service area

	Service Area 1		Service Area 2		Service Area 5		Service Area 6	
	Construction Cost ($1,000)	Salvage Value ($1,000)	Construction Cost ($1,000)	Salvage Value ($1,000)	Construction Cost ($1,000)	Salvage Value ($1,000)	Construction Cost ($1,000)	Salvage Value ($1,000)
Sewers	56	34	13	8	282	169	732	439
Storage	1,660	797	4,000	1,920	2,500	1,200	4,400	2,112
Pumping	136	65	360	173	184	88	400	192
Filtration	143	68	494	237	228	109	513	246
Disinfection	70	34	114	55	82	39	118	57
Backwash Storage and Piping	45	22	156	75	72	35	162	78
Sludge Handling	136	41	360	108	184	55	400	120
Land	100	100	150	150	100	100	150	150
Undeveloped Design Details (15%)	352	174	847	409	545	269	1,031	509
Total Estimated Construction Cost	2,698	--	6,494	--	4,177	--	7,906	--
Contingencies, Engineering, Legal, and Administrative (20%)	540	--	1,299	--	835	--	1,581	--
Total Estimated Project Cost	3,238	1,335	7,793	3,135	5,012	2,064	9,487	3,903
Operation and Maintenance Cost ($/yr)								
Storage and Treatment	$95,660/yr		$264,260/yr		$136,630/yr		$284,970/yr	
Combined Sewer Systems	2,240/yr		6,880/yr		2,040/yr		4,120/yr	
Total	$97,900/yr		$271,140/yr		$138,670/yr		$289,090/yr	

[1] Based on May 1979 costs.

Source: Stanley Consultants

Table 20 - Cost estimate[1] for alternative 6 - regionalized filtration treatment

	Construction Cost ($1,000)	Salvage Value ($1,000)
Sewers	20,700	12,420
Storage	3,659	1,756
Pumping	618	297
Filtration	627	301
Disinfection	134	64
Sewer for Waste Flow	166	99
Backwash Storage and Piping	198	95
Land	75	75
Undeveloped Design Detail (15%)	3,927	2,266
Total Estimated Construction Cost	30,104	17,373
Contingencies, Engineering, Legal, and Administrative (20%)	6,021	3,475
Total Estimated Project Cost	36,125	20,848
Operation and Maintenance Cost ($/yr)		
Storage and Treatment	$198,850/year	
Combined Sewer System	15,280/year	
Total	$214,130/year	

[1]Based on May 1979 costs.

Source: Stanley Consultants

Treatment efficiencies are anticipated to be the same as alternative 5 with 90 to 95 percent suspended solids and 75 to 85 percent BOD removal.

Alternative 7 - Sedimentation Treatment by Service Area

This alternative is identical to alternative 5 except that filtration facilities are not provided and treatment consists only of sedimentation and chlorination. It is estimated that the sedimentation facilities will remove 75 of 85 percent of the suspended solids and 50 to 60 percent of the BOD in the wastewater. Chlorination will reduce the coliform count to near zero.

Construction and operation and maintenance costs for alternative 7 are presented in table 21. The storage and sedimentation facilities account for more than 75 percent of the total construction cost.

The same disadvantages which apply to alternative 5 regarding lack of suitable construction sites and difficulty of sporadic operation also apply to this alternative.

Alternative 8 - Regionalized Sedimentation Treatment

This alternative uses the same treatment process as alternative 7 except that all of the combined wastewater is taken to a single site for storage and treatment. The same treatment site and collection system proposed for alternative 6 would be used for this alternative. It is estimated that, if properly maintained and operated, the sedimentation facilities will remove 75 to 85 percent of the suspended solids and 50 to 60 percent of the BOD in the combined sewer overflows.

Construction and operation and maintenance costs for alternative 8 are presented in table 22. The massive collection system required for this alternative accounts for approximately 80 percent of the construction cost.

Table 21 - Cost estimate[1] for alternative 7 - sedimentation treatment by service area

	Service Area 1		Service Area 2		Service Area 5		Service Area 6	
	Construction Cost ($1,000)	Salvage Value ($1,000)	Construction Cost ($1,000)	Salvage Value ($1,000)	Construction Cost ($1,000)	Salvage Value ($1,000)	Construction Cost ($1,000)	Salvage Value ($1,000)
Sewers	56	34	13	8	282	169	732	439
Storage and Sedimentation	1,660	797	4,000	1,920	2,500	1,200	4,400	2,112
Pumping	136	65	360	173	184	88	400	192
Disinfection	70	34	114	55	82	39	118	57
Sludge Handling	136	41	360	108	184	55	400	120
Land	80	80	120	120	80	80	120	120
Undeveloped Design Details (15%)	321	158	745	358	497	245	926	456
Total Estimated Construction Cost	2,459	--	5,712	--	3,809	--	7,096	--
Contingencies, Engineering, Legal, and Administrative (20%)	492	--	1,142	--	762	--	1,419	--
Total Estimated Project Cost	2,951	1,209	6,854	2,742	4,571	1,876	8,515	3,496
Operation and Maintenance Cost ($/yr)								
Storage and Treatment	$76,910/yr		$199,260/yr		$106,630/yr		$217,470/yr	
Combined Sewer System	2,240/yr		6,880/yr		2,040/yr		4,120/yr	
Total	$79,150/yr		$206,140/yr		$108,670/yr		$221,590/yr	

[1]Based on May 1979 costs.

Source: Stanley Consultants

Table 22 - Cost estimate[1] for alternative 8 - regionalized sedimentation treatment

	Construction Cost ($1,000)	Salvage Value ($1,000)
Sewers	20,700	12,420
Storage and Sedimentation	3,659	1,756
Pumping	618	297
Disinfection	134	64
Sewer for Waste Flow	166	99
Land	75	75
Undeveloped Design Details (15%)	3,803	2,207
Total Estimated Construction Cost	29,155	16,918
Contingencies, Engineering, Legal, and Administrative (20%)	5,831	3,384
Total Estimated Project Cost	34,986	20,302
Operation and Maintenance Costs ($/yr)		
Storage and Treatment	$126,350/year	
Combined Sewer System	15,280/year	
Total	$141,630/year	

[1]Based on May 1979 costs.

Source: Stanley Consultants

Alternative 9 - Swirl Concentrator Treatment

This alternative proposes placing swirl concentrators in each service area. Equalization storage facilities are not used for the inflow, and all facilities are sized to handle a 0.25-year design storm as described previously in this report. Treatment unit sizes are shown in table 23.

Table 23 - Unit sizes for alternative 9 - swirl concentrator treatment

	Service Area 1	Service Area 2	Service Area 5	Service Area 6
0.25-Year Design Storm Peak Flow Rate, cfs	33	96	52	105
Design Peak Pumping Capacity, cfs	33	96	52	105
Swirl Concentrator				
Design Flow Rate, cfs	16.5	48	26	52.5
Peak Hydraulic Rate, cfs	33	96	52	105
Chlorination Detention Time, minutes	15	15	15	15
Underflow Storage Volume, million gallons	.08	.28	.13	.29

Source: Stanley Consultants

It is anticipated that suspended solids removal efficiencies will generally be in the 20 to 50 percent range and that BOD removal will average 35 to 45 percent. Chlorination will be used to reduce the coliform count to near zero since the receiving water is used as a public water supply.

Cost estimates for this alternative are shown in table 24. Pumping facilities account for more than half of the construction cost. Operations and maintenance costs consist primarily of

Table 24 - Cost estimate[1] for alternative 9 - swirl concentrator treatment

	Service Area 1		Service Area 2		Service Area 5		Service Area 6	
	Construction Cost ($1,000)	Salvage Value ($1,000)	Construction Cost ($1,000)	Salvage Value ($1,000)	Construction Cost ($1,000)	Salvage Value ($1,000)	Construction Cost ($1,000)	Salvage Value ($1,000)
Pumping	1,110	533	2,562	1,230	1,464	703	2,806	1,347
Swirl Concentrator	77	37	224	108	112	54	245	118
Disinfection	220	106	403	193	268	129	415	199
Underflow (Storage and Mixing)	128	61	312	150	184	88	338	162
Piping	56	34	13	8	282	169	732	439
Land	25	25	50	50	25	25	50	50
Undeveloped Design Details (15%)	242	119	535	261	350	175	688	347
Total Estimated Construction Cost	1,858	--	4,098	--	2,685	--	5,274	--
Contingencies, Engineering, Legal, and Administrative (20%)	372	--	820	--	537	--	1,055	--
Total Estimated Project Cost	2,230	915	4,918	2,000	3,222	1,343	6,329	2,662
Operation and Maintenance Cost ($/yr)								
Treatment Facility	$68,920/yr		$160,870/yr		$ 92,250/yr		$174,910/yr	
Existing Combined Sewer System	2,240/yr		6,880/yr		2,040/yr		4,120/yr	
Total	$71,160/yr		$167,750/yr		$ 94,290/yr		$179,030/yr	

[1] Based on May 1979 costs.

Source: Stanley Consultants

power for pumping, chlorine, and labor for maintaining the facilities. As with alternatives 5 and 7, it is difficult to identify suitable construction sites for this alternative.

No Action Plan

The no action plan calls for no changes to the existing combined sewer overflow problem. Combined sewer overflows would continue to deliver approximately 265,700 pounds of BOD per year to the Red River of the North. The water quality of the receiving water would not improve and may deteriorate because of the compounding effects of increased pollution loads from development of upstream areas. Water quality of the Red River at Grand Forks would continue to be a public health concern. Street flooding and basement backups will also continue to occur in the combined sewer area. However, there are no costs associated with this alternative.

Relocate Water Intakes

The combined sewer overflows appear to have an adverse impact on the water supply quality because of their proximity to the Grand Forks water supply intakes. Relocating water intakes upstream of combined sewer overflows may result in improved water quality to the Grand Forks water supply system during storm events and low-flow periods. The amount of improvement depends on the degree of backwater effect in the pool area. It is estimated that combined sewer overflows contribute as much as 265,700 pounds per year of BOD to the receiving water. If this alternative is implemented, the basic problem of combined sewer overflows will not be eliminated. However, the combined sewer overflows will not be discharged near the water intakes, and an improvement in water supply quality is expected during storm events and low-flow periods.

The cost estimate for this alternative is $3,559,000. This estimate includes an intake structure, a pump station, and a new raw water main. The water main cost is the most significant

item for this alternative. Operation and maintenance costs would be relatively low with routine maintenance of pumps and water mains being the only requirement.

Collection System and Source Mangaement

Collection system and source management are considered as a complement to other developed alternatives. Collection system management is not very applicable in the study area because of the physical nature of the combined sewer overflow control structures. Source management by means of street cleaning, sewer flushing, and catch basin cleaning is an aid in reducing pollutants in stormwater runoff.

Sewer flushing is particularly beneficial to sewers with very flat slopes, as is the case in Grand Forks. Catch basin cleaning twice a year can reduce the total level of pollutants washed from the street by 15 to 20 percent.(8) However, with a regular street cleaning program the need for catch basin cleaning is minimized. Typical removals possible by street cleaning are shown in table 25, based on once a week cleaning of 116,900 feet of curb and an average unit cost of $16/curb mile.

Table 25 - Cost and removal by street cleaning[1]

Pollutant	Average Removal (lbs/curb mile)	Removal (lbs/yr)	Removal Cost ($/yr)
BOD	12	13,790	18,400
TSS	100	114,920	

[1]Based on once a week cleaning.

Source: Stanley Consultants and Reference 11

The city of Grand Forks has four street sweepers. Due to staff limitations, three of the sweepers are generally operated during approximately 7 months of the year. The downtown streets are swept three to five times per week. The remaining area is swept, on the average, once a week. This is a relatively good program, and the city could benefit by the continuation of this regular cleaning program. As stated earlier, the need for catch basin cleaning can be minimized by an effective street cleaning program.

Grand Forks is relatively flat and thus the sewers have rather flat slopes. This has necessitated sewer flushing in certain areas to remove sediment and debris. Sewer flushing of combined sewers will wash pollutants into the pump stations where they will be pumped to the wastewater treatment plant. If the sewer system is separated, sewer flushing will not affect the quantities washed into the Red River.

The relatively low cost of this alternative compared to the other developed alternatives makes this option attractive. It should be noted, however, that the environmental benefits in terms of pollutant removal are limited.

IMPACT ASSESSMENT

This section summarizes the impact assessment of the alternatives that were selected for detailed evaluation. The environmental, social, and economic changes associated with each alternative are identified and measured. The impact assessment is summarized in matrix form.

Table 26 is the impact analysis matrix for sewer separation and treatment alternatives. To facilitate the analysis, the alternatives have been listed in table 26 under the following headings:

1. No action - No improvements to the existing combined sewer system are made under the no action alternative

Table 26 - Impact assessment

Impact	No Action	Sewer Separation Alternatives 1, 2, 3, & 4	Treatment by Service Area Alternatives 5, 7, & 9	Regionalized Collection and Treatment Alternatives 6 & 8	Relocate Water Intakes	Street Sweeping
Environmental						
Land	No effect.	No effect.	Land required downtown.	Up to 15 acres required.	No effect.	No effect.
Natural Resources	No effect.	Consumptive use of energy during construction.	Consumptive use of energy during construction and for pumping, and chemicals for treatment.	Consumptive use of energy during construction and for pumping, and chemicals for treatment.	Consumptive use of energy during construction. No significant change in pumping requirements due to relocation. Slight decrease in treatment requirements.	Consumptive use of energy to operate sweepers.
Man-made Resources	No effect.	Alternatives 1, 2, & 3 utilize existing sewer.	May remove existing buildings.	May disrupt Riverside Park.	Existing intakes will be replaced.	No effect.
Water Quality	No change.	Improved. May be degraded during construction.	Improved. May be degraded during construction.	Improved. May be degraded during construction.	No change. May be degraded during construction.	Improved.
Air Quality	No effect.	Increased dust during construction.	Increased dust during construction.	Increased dust during construction.	Increased dust during construction.	Increased dust during sweeping possible.
Wildlife	No effect.	Disturbed during construction.	Disturbed during construction.	Disturbed during construction.	Disturbed during construction.	No effect.
Hydrological	No change.	Slight reduction in hydraulic load to sewage lagoon.	No change.	No change.	No change.	No change.
Public Health	No change.	Improved.	No change in study area. Improvement related to Red River of the North.	No change in study area. Improvement related to Red River of the North.	No change.	Improvement related to Red River of the North.
Social						
Noise	No effect.	Increased during construction.	Increased during construction.	Increased during construction.	Increased during construction.	Increased during sweeping.
Displacement of People	No effect.	No effect.	Possible, depends on site.	No effect.	No effect.	No effect.
Aesthetics	No change.	Eliminates basement flooding. Alternatives 2, 3, & 4 reduce street flooding. Decreased during construction.	Decreased at treatment sites. Improvement related to Red River of the North.	Decreased at treatment site. Improvement related to Red River of the North.	Decreased during construction.	Improved.
Historical & Archaeological	No effect.	No effect.	Depends on site. No known effect.	No known effect.	No known effect.	No effect.
Transportation	No change.	Increased and disrupted during construction.	Increased and disrupted during construction.	Increased and disrupted during construction.	Increased and disrupted during construction.	Possible disruption during sweeping.
Institutional Relationships	No effect.	No change.	No change.	No effect.	No effect.	No effect.
Community Cohesion	No effect.	May improve.	No effect.	No effect.	No effect.	No effect.
Community Growth	No effect.	No effect.	No effect.	No effect.	No effect.	No effect.
Public Acceptance	No change.	Improved. Decreased during construction.	Decreased	Decreased.	Decreased.	Improved.
Economic						
Public Facilities	No effect.	No effect.	No effect.	No effect.	No effect.	No effect.
Public Services	No change.	Improved.	Improved slightly.	Improved slightly.	No change.	Improved.
Employment	No effect.	Increased during construction.	Increased during construction and for operation of facilities.	Increased during construction and for operation of facilities.	Increased during construction.	Increased slightly.
Business and Industrial Activity	No change.	Disrupted during construction.	No change.	No change.	Disrupted during construction.	No change.
Tax Revenues	No effect.	Slight increase.	Slight decrease.	Slight decrease.	No change.	No effect.
Property Values	No change.	Improved.	Slight decrease locally.	Slight decrease locally.	No change.	No change.

Source: Stanley Consultants

2. Sewer separation - Alternatives 1, 2, 3, and 4 are included under this heading.
3. Treatment by service area - This heading includes each of the alternatives considered for treatment of combined sewer overflow at the outfall sites. This includes alternatives 5, 7, and 9.
4. Regionalized collection and treatment - Alternatives 6 and 8 represent the collection of all combined sewer overflow and treatment at a single location.
5. Relocate water intakes.
6. Street sweeping.

No Action Plan

Environmental Factors - No change to existing environmental conditions is expected to occur to items listed in this category. Since the combined sewer area under study in Grand Forks is almost entirely developed, the quantity and quality of future waste loads discharged into the Red River of the North under the no action alternative are expected to be similar to those of present loads. Combined sewer overflows contain suspended organic and inorganic solids, dissolved organic materials, nutrients, heavy metals, pathogens, oils and greases that will continue to adversely affect aquatic life in the river. The oxygen demand created by the organic materials can lower the dissolved oxygen levels in the river below those suitable for desirable freshwater aquatic streams.

Street flooding and basement backups will continue to occur in the combined sewer area. A potential threat to public health exists whenever people contact the pathogens associated with this type of flooding during cleanup activities.

Social Factors - The no action alternative is not expected to change the impacts on items considered in this category. The problems associated with street flooding and

basement backups will continue to create undesirable aesthetic impacts.

Economic Factors - No change to the economic status of the study area is expected by implementing the no action alternative. Since there is no improvement to the sewer system, the condition of sewer service in the area remains unchanged. Property values in the area may be slightly depressed, reflecting the undesirability of basement backups and street flooding.

Sewer Separation

Environmental Factors - Table 26 shows that both short-term and long-term environmental impacts are associated with the alternatives for sewer separation. Short-term impacts result from construction of the new sewer lines. Construction could have adverse impacts on biological resources. During the excavation of trenches, tree roots and landscaped areas may be damaged or disturbed. The operation of trucks and heavy equipment during construction will consume energy. Locally high levels of suspended particulates will be found near the construction activities. The construction of sanitary and/or storm sewers has a relatively low potential for significant erosion and sediment control problems. The generally flat topography in the project area also reduces erosion potential. The plans and specifications will be prepared so that erosion and sediment runoff caused by construction will be minimized.

Since sewer separation will eliminate basement backups, reduce street flooding, and reduce the potency of waste discharged into the Red River of the North, important long-term beneficial impacts result. Water quality of the river will improve since all of the sanitary wastes will be carried to the sewage lagoon for treatment. Although large reductions in pollutant concentrations (fecal coliform, BOD, and nutrients) are expected to occur in stormwater discharged to the river,

suspended solids levels may actually increase in the storm sewer discharge. Many of the heavier solids associated with the storm runoff, which are currently diverted by the overflow structures to the wastewater treatment plant, would be confined to the storm sewer system and go directly to the river. However, the organic solids associated with sanitary wastes will no longer be discharged to the river. Discharge of suspended solids due to storm runoff will continue to have an adverse effect on water quality in the river.

Alternatives 1, 2, and 3 use all or part of the existing combined sewer system. Use of the existing system promotes conservation of a man-made resource. This beneficial impact is not experienced with alternative 4 since the existing sewer system would be abandoned.

Separation of sanitary and storm sewers reduces substantially the threat to public health posed by pathogens associated with basement backups and street flooding. Basement backups will be eliminated with each alternative, and street flooding would be greatly reduced with alternatives 2 and 4. Street flooding may continue with alternatives 1 and 3, but the reduced pathogen levels will lessen the threat to public health.

Social Factors - No impact on land use, population, historic or archaeological sites, institutional relationships, and community growth is expected with sewer separation. Construction activities will locally raise noise levels. In addition, construction will disrupt traffic flow and inconvenience local residents. This may harm public acceptance of this project initially.

Once sewer separation is complete, the aesthetics perceived by the people who in the past had experienced basement backups and serious street flooding should be greatly enhanced.

Community cohesion may improve slightly since the affected people may feel that the city is responding positively to their needs. Long-term public acceptance of this action should be high.

Economic Factors - A short-term economic impact related to sewer construction includes the disruption of business and industrial activities. However, the local economy may benefit a small amount by an increased construction labor force and by the purchase of goods and services by the construction personnel.

Long-term beneficial economic impacts will be felt in the study area because separation of storm and sanitary sewers will improve public services provided by the city. Elimination of basement backups could result in a slight increase in property values as affected properties become more desirable. This property value increase may be reflected in slightly higher tax revenues from the study area.

Treatment by Service Area

Environmental Factors - As shown in table 26, construction of facilities for treatment by service area would have primary environmental impacts. Increased levels of fugitive dust in residential areas are expected with the construction activities. The proximity of the treatment facilities to the Red River of the North could increase the sediment load to the river from soil washed from the construction area. Measures would be taken during design and construction to minimize erosion and sediment runoff.

Impacts on biological resources are construction oriented. Treatment facilities will be located in predominantly residential areas so construction activities may damage or disturb tree roots or landscaped areas. Disturbed areas can be restored after completion of construction.

Energy will be consumed by trucks and heavy equipment during construction. Long-term energy use will be incurred by pumping and chemical requirements during combined overflow treatment.

Some improvement in water quality in the Red River of the North is a beneficial long-term impact of treatment by service area. However, since a high level of treatment will not be provided, quantities of pollutants will continue to be discharged into the river.

Approximately two acres of land must be made available at each of four combined sewer overflow locations for the filtration and sedimentation alternatives. Treatment with swirl concentrators requires less land. The treatment sites would be located near the Red River of the North in heavily developed areas of Grand Forks. Use of this land for treatment facilities makes it unavailable for commercial, residential, or recreational activities. At some sites it may be necessary to remove existing buildings or locate the treatment facilities in existing parks.

These treatment alternatives do not eliminate the problem of basement backups and street flooding; flooding and backups will occur whenever storage capacity is exceeded. These occurrences will continue to subject people to high levels of pathogens found in combined sewers, posing a continued threat to public health. However, treatment will reduce the level of pathogens and other contaminants discharged to the Red River of the North, resulting in some improvements to the public health in association with river oriented activities.

Social Factors - Construction of the treatment facilities for combined sewer overflows will produce local short-term impacts. The operation of heavy equipment in a developed area of the city will increase noise levels. Truck traffic will also increase.

The location of treatment facilities near businesses or residences may have an adverse long-term impact on the aesthetics of the area. A buffer and attractive landscaping could minimize the aesthetic degradation. The problem could become more significant if odors form while the combined sewer overflow is detained in sedimentation basins. However, improved aesthetics related to the Red River of the North can be expected due to decreased discharges of suspended solids, fecal coliforms, BOD, and floating material. People or businesses may be displaced to provide sufficient room for treatment facilities. Decreased public acceptance is expected since considerable capital expenditure is to be made without completely solving the problem of basement backups and street flooding.

Economic Factors - A small stimulus to the local economy may occur from an increased number of workers and their purchase of goods and services.

Grand Forks will most likely be required to purchase privately owned land to provide room for the treatment facilities. A long-term economic impact of this action would be a reduction of the city's tax base and decreased tax revenue. Property values may drop slightly in the vicinity of the treatment facilities causing an additional minor decrease in tax revenues.

Regionalized Collection and Treatment

Environmental Factors - Enivronmental impacts associated with regionalized collection and treatment of combined sewer overflows are shown in table 26. Short-term impacts created by the construction of the overflow interceptor and the treatment facility include the release of dust in residential areas, the use of energy to operate trucks and heavy equipment, and the disruption or damage to trees and landscaped areas. The proposed route of the interceptor line to the treatment facility passes through Riverside Park. Construction activities

may necessitate the removal of trees and other park resources. Preventive measures would be taken during the design and construction to minimize the problem of erosion and sediment runoff.

Regionalized collection and treatment of combined sewer overflows will result in a long-term improvement in the water quality of the Red River of the North. Some pollutants will still be discharged into the river since a high level of treatment is not being proposed. Resource requirements for treatment will consist of electricity for pumps and chemicals at the treatment facility.

Up to 15 acres of land is needed for the treatment facility along the Red River of the North just upstream of the confluence with the English Coulee. This land would be purchased by the city, precluding its use for private development.

Regionalized collection and treatment of combined sewer overflows does not eliminate the problem of basement backups and street flooding. Once storage capacity is exceeded, flooding and backups will still occur. A potential threat to public health in the study area will continue from exposure to high levels of pathogens. Since a reduction in pathogens and other contaminants will result from treatment, the threat to public health will be reduced during water related activities. Also, the discharge from the treatment facilities would be located downstream from all of the Grand Forks water intakes.

Social Factors - The only short-term social impacts associated with regionalized collection and treatment of combined sewer overflows is the increase in noise, dust, and energy consumption related to the use of trucks and heavy equipment during construction. Construction activities may disrupt traffic for short periods as streets are blocked for installation of the interceptor sewer.

No people should be displaced as a result of this action. A problem with decreased aesthetics may arise near the sedimentation basin, particularly if odors form. However, the aesthetics associated with the Red River of the North will improve since treatment will reduce the amount of objectionable contaminants discharged into the river. This project will suffer from decreased public acceptance since a considerable capital expenditure is required and the problem of basement backups and street flooding has not been totally eliminated.

Economic Factors - A small stimulus to the local economy may result as an increased number of workers will purchase goods and services from area businesses.

Purchase by Grand Forks of up to 15 acres of privately owned land will remove this land from the city's tax base. A long-term adverse economic impact will be a decrease in city tax revenues.

Relocate Water Intakes

Environmental Factors - This alternative requires construction of a new water intake and a new water line to the water treatment plant. There is very little construction involved with relocating the water intake, as compared to alternatives 1-9. Because the new intake would be located upstream of existing overflows, the raw water supply would be improved, and treatment requirements would be reduced. Some environmental impacts can be expected during construction: wildlife could be disturbed, and locally high levels of suspended particulates will be found near the construction activities. Trucks and equipment involved with construction will consume energy.

Social Factors - No effect to land use, population, historic or archaeological sites, or institutional relationships is expected. Traffic and noise would be increased during

construction of the intake structure and transmission line. Disruption of traffic during construction of a new transmission line will occur, because existing streets must be crossed and blocked. Aesthetics may be diminished during construction activities.

Economic Factors - No change to property values, tax revenues, public services, or public facilities is expected. Business or industrial activity may be disrupted during construction. But construction activities will provide additional jobs.

Street Sweeping

Grand Forks currently does some street sweeping and impacts are assessed based on the continuation or expansion of their current program as compared to no action.

Environmental Factors - Street sweeping will remove pollutants before they may enter the storm sewer system and the receiving stream. Sweeping will have no impact on land use, man-made resources, hydrology or wildlife. Street sweepers will consume energy, and will increase dust levels locally during sweeping operations.

Social Factors - Street sweeping will improve aesthetics of the area by periodically removing debris that collects in the streets. The public acceptance would be favorable to this type of positive action that improves the streets' appearance. Noise will be increased locally during sweeping, and traffic can possibly be disrupted. No impact on population, historical or archaeological sites, institutional relationships, or community cohesion is expected.

Economic Factors - Street sweeping provides a public service to a community. It can also provide jobs. No impact on public facilities, business and industrial activity, tax revenues or property values is expected.

PLAN SELECTION

GENERAL

This part of the report presents a summary and ranking of the alternatives developed and considered in detail. Based on these rankings, a plan is selected as representing the most cost-effective and environmentally acceptable approach for eliminating or significantly reducing the combined sewer overflow problem for Grand Forks.

PUBLIC PARTICIPATION

Two public hearings were held on 3 March 1980 in the Grand Forks City Hall for this project. Notices were published 30 days prior to the hearings. The first hearing addressed the alternatives which were developed in this study and the alternative configurations and costs were presented. The second public hearing presented the environmental impacts of the various alternatives and the recommended plan. The purpose of the hearings was to familiarize people with the study and to obtain formal comments from all concerned interests. Nineteen people attended the public hearings. There were no adverse comments regarding the selected plan. Several questions were asked regarding financing of the project. A summary of the public hearing is contained in attachment B.

EVALUATION AND RANKING OF ALTERNATIVES

Alternatives were presented earlier in this report. These alternatives were developed in such a manner that different alternatives could be implemented for each of the

service areas. Table 27 is a list of the developed alternatives.

Table 27 - Developed alternatives

Alternative	General Description
1	New sanitary sewer system, retaining existing system as storm sewer system.
2	New storm sewer system, retaining existing system as sanitary sewer system.
3	New sanitary and new storm sewer systems, retaining existing system as sanitary or storm sewer in appropriate locations.
4	New sanitary and new storm sewers, abandoning the existing combined sewer system.
5	Filtration treatment by service area.
6	Regionalized filtration treatment.
7	Sedimentation treatment by service area.
8	Regionalized sedimentation treatment.
9	Swirl concentrators by service area.
	Relocate water intakes.
	Street sweeping.

Source: Stanley Consultants

Cost estimates of the developed alternatives have been summarized in table 28. All costs have been converted to a present worth and an equivalent annual cost based on a 6 7/8 percent interest rate. Table 29 gives the pounds of BOD removed per year and the unit cost per pound of BOD removed for each alternative. The costs per pound of BOD removed shown in table 29 are heavily dependent upon the estimated BOD removal. The unit costs are not intended as absolute values

Table 28 - Alternative cost estimate summary

Alternative[1]	Service Area	Initial Cost ($1,000)	O&M ($1,000/yr)	Salvage Value ($1,000)	Total Present Worth ($1,000)	Equivalent Annual Cost ($1,000/yr)
1	1	1,625	3	807	1,444	135
	2	5,474	9	2,720	4,851	454
	5	2,110	3	1,048	1,865	174
	6	4,763	7	2,366	4,212	394
	Total	13,972	22	6,941	13,372	1,157
2	1	1,744	5	851	1,572	147
	2	7,136	17	3,497	6,393	598
	5	2,044	5	1,002	1,832	171
	6	6,123	12	2,999	5,458	510
	Total	17,047	39	8,349	15,256	1,426
3	1	1,625	3	807	1,444	135
	2	6,089	9	3,026	5,385	503
	5	2,486	3	1,235	2,191	205
	6	8,087	9	4,000	7,125	666
	Total	18,287	24	9,068	16,145	1,509
4	1	2,954	3	1,475	2,596	243
	2	11,234	9	5,612	9,846	921
	5	3,727	3	1,862	3,267	305
	6	9,647	8	4,821	8,457	791
	Total	27,562	23	13,770	24,166	2,260
5	1	3,238	98	1,335	3,933	368
	2	7,793	271	3,135	9,862	922
	5	5,012	139	2,064	5,953	557
	6	9,487	289	3,903	11,546	1,080
	Total	25,530	797	10,437	31,294	2,927
6		36,125	214	20,848	32,899	3,076
7	1	2,951	79	1,209	3,476	325
	2	6,854	206	2,742	8,332	779
	5	4,571	109	1,876	5,241	490
	6	8,515	222	3,496	9,965	932
	Total	22,891	616	9,323	27,014	2,526
8		34,986	142	20,302	31,135	2,911
9	1	2,230	71	796	2,779	260
	2	4,918	168	1,739	6,255	585
	5	3,222	94	1,168	3,918	366
	6	6,329	179	2,315	7,631	714
	Total	16,699	512	6,018	20,583	1,925
Relocate Water Intakes		3,559	66	1,724	3,809	356
Street Sweeping[2]		120	18	112	375	35

[1]See table 27 for alternative descriptions.

[2]112,000 is not a salvage value, but a replacement cost for street sweepers.

Source: Stanley Consultants

Table 29 - Unit cost of pollution removal

Alternative[1]	Service Area	Equivalent Annual Cost ($1,000/yr)	BOD Removed (1,000 lb/yr)	Unit Cost for Removal ($/lb BOD)
1	1	135	22	6.14
	2	454	77	5.90
	5	174	35	4.97
	6	394	79	4.99
	Total	1,157	213	5.43
2	1	147	22	6.68
	2	598	77	7.77
	5	171	35	4.89
	6	510	79	6.46
	Total	1,426	213	6.69
3	1	135	22	6.14
	2	503	77	6.53
	5	205	35	5.86
	6	666	79	10.01
	Total	1,509	213	10.91
4	1	243	22	11.05
	2	921	77	11.96
	5	305	35	8.71
	6	791	79	8.43
	Total	2,260	213	7.08
5	1	368	21	17.52
	2	922	72	12.81
	5	557	33	16.88
	6	1,080	74	14.59
	Total	2,927	200	14.64
6		3,076	200	15.38
7	1	325	14	23.21
	2	779	48	16.23
	5	490	22	22.27
	6	932	49	19.02
	Total	2,526	133	18.99
8		2,911	133	21.89
9	1	260	10	26.00
	2	585	35	16.71
	5	366	16	22.88
	6	714	38	18.79
	Total	1,925	99	19.44
Relocate Water Intakes[2]		356	--	--
Street Sweeping		35	14	2.50

[1]See table 27 for alternative descriptions.

[2]No removal takes place.

Source: Stanley Consultants

but rather are presented as a relative comparison between the alternatives. The cost per pound of BOD removed is plotted for each alternative and presented on figure 17.

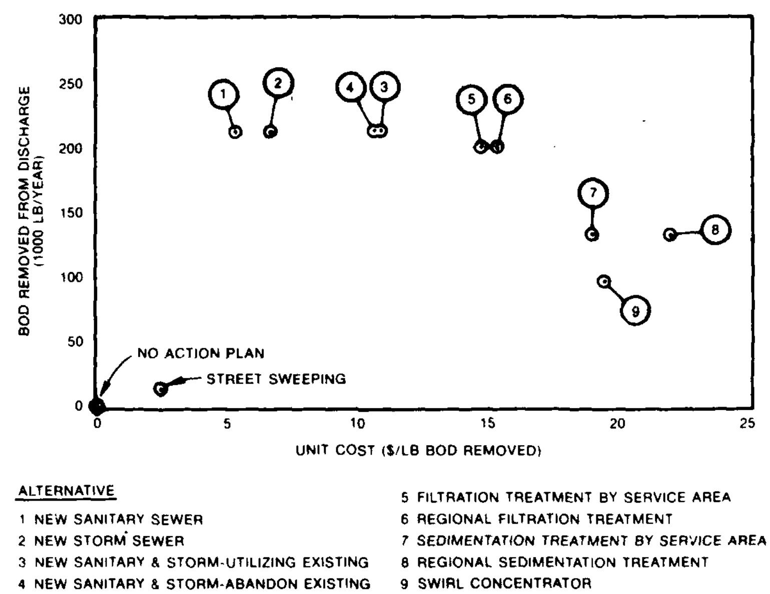

Figure 17 - Cost Per Pound of BOD Removed

Selection of the best alternative requires careful consideration of environmental, social, economic, and institutional factors. There is no common unit of measure between factors. Therefore, a rigorous analytical technique for ranking the alternatives is lacking. For the purpose of this study, table 30 was developed to assist selection by providing a general comparison of acceptability among alternatives. Emphasis on absolute numbers should be avoided in reviewing table 30.

Table 30 - Ranking of alternatives

	No Action	Sewer Separation: Sanitary Sewer Alt. 1	Sewer Separation: Storm Sewer Alt. 2	Sewer Separation: Sanitary & Storm Alt. 3	Sewer Separation: Sanitary & Storm Alt. 4	Treatment by Service Area: Filtration Alt. 5	Treatment by Service Area: Sedimentation Alt. 7	Treatment by Service Area: Swirl Concentrators Alt. 9	Regionalized Collection and Treatment: Filtration Alt. 6	Regionalized Collection and Treatment: Sedimentation Alt. 8	Other: Relocate Water Intakes	Other: Street Sweeping
	Rank of Alternatives[1&2]											
Monetary Costs	5	3	2	2	1	1	1	2	1	1	5	5
Environmental Effects	0	4	5	5	5	2	2	2	3	3	1	1
Contribution to Goals	0	4	5	5	5	3	2	1	3	2	1	2
Feasibility	--	5	5	5	3	2	2	1	3	3	4	5
Reliability	--	5	5	5	5	2	2	2	3	3	3	3
Implementation Capability	--	5	5	5	5	2	2	2	3	3	5	5
Public Acceptability	1	5	5	5	4	2	2	1	3	3	1	5
Resource Requirements	5	4	4	4	4	3	3	3	3	3	3	4
Totals	11	35	36	36	32	17	16	14	22	.1	23	30

[1]See table 27 for description of each alternative.

[2]Alternatives are ranked from 1 to 5 with the higher numbers assigned to alternatives that rank the highest.

Source: Stanley Consultants

Each alternative is assigned a number from 0 to 5 for each factor. More than one alternative is assigned the same number where the factor results in similar effects. The higher numbers are assigned to the alternatives which rate higher, i.e., least cost, least resource requirements, best contribution to goals. Alternatives which rank high on the table are more desirable than alternatives with lower rankings. Care must be used in selecting a final plan when alternatives have similar rankings.

Some short-term adverse environmental impacts are associated with each alternative during construction. The sewer separation alternatives have higher environmental rankings in table 30 than the treatment alternatives since, in addition to reducing pollutant loads to the Red River, they also eliminate basement backup. The treatment alternatives have adverse environmental impacts associated with the facilities being located in parks and residential areas. The sewer separation alternatives rank higher in contribution to goals since they eliminate the basement backups and, in some cases, eliminate street flooding. The treatment alternatives rank lower than separation alternatives on feasibility because of problems associated with constructing treatment facilities capable of operating over wide flow ranges on a sporadic basis. The reliability of the treatment facilities is also not as high as for sewer systems. The treatment facilities would be difficult for Grand Forks to properly operate because skilled operators would have to be available on short notice. The sewer separation alternatives would be constructed on existing city right-of-way. The treatment facilities would have to be constructed on park land or other property which is not currently owned by the city. It is anticipated that there would be resistance to building treatment facilities in parks or in residential areas; the treatment

alternatives therefore rank relatively low on implementation capability and public acceptability. The treatment alternatives also rank slightly lower than sewer separation alternatives for resource requirements since electrical power and chemicals are required for operation of the treatment facilities.

Implementation of the no action plan would allow the continued discharge of untreated combined sewer overflows into the Red River of the North and would not meet the requirements of the city's NPDES discharge permit. The no action plan would result in continued degradation of the river's water quality by the continued discharge of combined sewer overflows. The no action plan does nothing to mitigate the problems of basement backups, street flooding, and the potential risk to public health from exposure to pathogens. Even though there is no capital expenditure, the public's acceptance of a no action plan is anticipated to be low. Therefore, the no action plan ranks low in table 30 and is not recommended for selection.

Present worth values for alternatives 5, 7, and 9 (treatment by service area) are less than the costs for regionalized collection and treatment but more than sewer separation. Since the problems of basement backups and street flooding are not mitigated, public acceptance of alternatives 5, 7, and 9 would be quite low. Because of the many disadvantages of treatment by service area, alternatives 5, 7, and 9 rank poorly in table 30 and are not recommended as the selected plan.

The high cost for regionalized collection and treatment produces a low ranking relative to sewer separation, as shown in table 30. Alternatives 6 and 8 do nothing to reduce basement backups and street flooding with combined sewage. Water quality in the Red River of the North will improve. However, a high level of treatment is not proposed, particularly with sedimentation, so some pollutants will continue to be discharged

into the river. The discharges will be located downstream from the water supply intakes for Grand Forks and, therefore, will not have an adverse impact on the drinking water quality. The operation of the treatment facility will require the increased consumption of resources. Implementation of a regionalized collection and treatment system for combined sewer overflows is expected to receive relatively low public acceptance. Therefore, alternatives 6 and 8 receive low rankings and are not recommended.

The alternative to relocate the water intakes ranks in the middle in table 30. This alternative has no effect on the amount of pollutants discharged into the Red River but rather it moves the water intake to minimize the effect of the combined sewer overflows on the drinking water quality. This alternative will not reduce basement backups or street flooding and does nothing to meet requirements of Grand Forks' current NPDES discharge permit. Relocating the water intakes is less costly than alternatives 1 through 9. However, because of the extremely limited benefits of this plan, it is not recommended for implementation.

Table 30 shows that the four sewer separation alternatives rank the highest. Sewer separation provides the greatest benefits since it eliminates sewer backups and reduces street flooding. In addition, the discharge of untreated combined sewage into the Red River of the North is eliminated.

Sewer separation is the plan that is most compatible with the city's current program to upgrade the sewer system. Even though alternatives 1, 2, and 3 are essentially ranked the same, there are small differences between them. The main advantages of a new sanitary sewer system include lower cost, minimum quantities of infiltration and inflow, and minimum maintenance requirements. This system will allow nearly the same level of

street flooding to continue that is currently experienced. Therefore, this alternative does not fully satisfy the project goals. If a new storm sewer system is constructed, the combined sewer system will be used for sanitary service. The combined sewers are considerably larger than required for a separate sanitary system, and sanitary wastes deposited in the old combined sewers will no longer be flushed out by storms. A sewer flushing program would probably be required on a periodic basis to keep the combined sewers free of excessive deposits. The main advantage of the new storm sewer system is that street flooding would be greatly reduced. This would satisfy all of the goals of the project. Alternative 3 maintains similar advantages but at a higher cost.

Alternative 4 is ranked lower than alternatives 1, 2, and 3. In comparison, this alternative is costly, abandons a usable sewer system already in place, and is anticipated to be not readily accepted by the public. Although alternative 4 ranks relatively high in table 30, alternatives 1, 2, and 3 are recommended to be utilized in the selected plan.

The street sweeping alternative is relatively inexpensive to implement and has a lower unit cost per pound of BOD removed than the other alternatives. The total quantity of pollutants which can be removed with this alternative is somewhat limited since only the pollutants which wash off of the streets can be removed. The street sweeping alternative can be used to complement the sewer separation alternatives since the pollutants which are removed by street sweeping would continue to be carried into the Red River in the storm sewer system after separation is complete. Continuation of an effective street sweeping program is recommended as a part of the selected plan.

PLAN SELECTION

The selected plan consists of a combination of sewer separation alternatives 1, 2, and 3 complemented by an effective street sweeping program. The recommended sewer separation plan for each service area is presented in the following paragraphs. During final design, detailed field surveys will be conducted to establish the exact condition, location, and elevations of all of the existing sewer lines. In addition, existing utilities and other potential conflicts will be identified. The detailed information that will be developed may indicate areas where the proposed pipe routings should be changed to avoid conflicts. There may also be situations where it will be desirable to change individual sewer line recommendations from new storm to new sanitary service and vice versa. Any changes of this nature made during final design would be intended to improve the configuration of the selected plan and make it easier to implement. The following recommendations are intended to be flexible such that minor changes can be implemented during the final design phase.

Service Area 1

Service Area 1 has an adequate existing system for storm flows. As indicated in table 30, alternative 1 has a favorable ranking in terms of socioeconomic factors. It is the least costly alternative, while providing a high level of protection from surface flooding. These factors result in the recommendation of alternative 1 for Service Area 1.

Service Area 2

The least costly alternative for this service area is alternative 1, which provides for a new sanitary sewer system. But, because of the low level of protection from surface flooding provided by the existing system, alternative 1 is not the recommended alternative. Alternative 3 provides a higher level of protection at a relatively small increase in cost. Alternative 3 consists of

a new sanitary system, with a new main line storm sewer section providing relief capacity for portions of the existing combined system used for storm service. The level of detail possible in this study did not permit a detailed inspection and evaluation of the condition of the existing combined sewers. In the final design, it may be deemed appropriate to use some existing combined lines as sanitary sewers and construct new storm sewers. Table 30 gives a favorable ranking to alternative 3. Because of the relatively low cost, favorable ranking, and high level of surface flooding protection, alternative 3, or a variation of it, is the recommended plan for Service Area 2.

Service Area 5

The least costly alternative for Service Area 5 is alternative 2, which provides for a new storm sewer system retaining the existing system as a sanitary system. This alternative is given the highest socioeconomic rankings as shown in table 30 and provides the highest level of protection against surface flooding. Because of the high ranking, least cost, and degree of flood protection provided, alternative 2 is recommended for Service Area 5. More detailed evaluation during the final design phase may identify individual combined sewer lines which could be incorporated into the storm sewer system while being replaced with smaller diameter sanitary sewers.

Pump station 2, which serves a portion of Service Area 5, is located in Central Park. It is subject to flooding and should either be flood proofed or replaced with a new pump station located on the dry side of the levee. In order to flood proof the pump station, it would be necessary to construct a levee approximately 8 feet high around the structure. The levee would take additional park land out of service. Because of the flood proofing required to use the existing pump station location, it is probably less expensive to construct a new pump

station on the dry side of the existing levee. The pump station would be quite small and could be constructed adjacent to the levee on existing city property. The pump station could either be constructed as a package unit or it may be possible to reuse the existing pumps and put them in a new structure. More detailed evaluation during the final design phase can determine the best configuration for this pump station.

Service Area 6

The least costly alternative for Service Area 6 is alternative 1 which consists of a new sanitary sewer system. A new storm sewer system (alternative 2) is the second least costly alternative and is estimated to cost $1,360,000 more than a new sanitary sewer system. The storm carrying capacity of the existing combined sewer system is inadequate by today's standards and, if alternative 1 is selected, this area will continue to experience street flooding problems. However, either alternative will eliminate basement backups of combined sewage since the system will be separated. The main advantages of a new sanitary system include lower cost, minimum quantities of infiltration and inflow, and minimum maintenance requirements. Because of its lower cost and several other advantages, alternative 1 is recommended for the selected plan. However, input from local citizens could change this recommendation. If street flooding were a serious problem to people living in the area and they were willing to pay the additional cost for a new storm sewer system, alternative 2 could be implemented instead of alternative 1. More detailed evaluation during final design may also identify individual combined sewer lines which should be incorporated into the new sanitary sewer system while being replaced with larger storm sewer lines to relieve localized street flooding.

SUMMARY OF SELECTED PLAN

The selected plan consists of a combination of sewer separation alternatives for the various service areas complemented by an effective street sweeping program. The selected plan is shown on figure 18. Table 31 summarizes the selected alternative for each service area along with construction and operation and maintenance costs. Construction of a new pump station to serve part of Service Area 5 is estimated to cost approximately $25,000. The pump station will replace an existing pump station so no additional operation and maintenance costs are involved. Continuation of an effective street sweeping program will cost approximately $70,000 for new street sweeping equipment and will involve an annual operation and maintenance cost of about $18,000.

Table 31 - Selected plan

Service Area	Selected Alternative	Project Cost. ($x1,000)	Operation and Maintenance Cost ($/year)
1	1	$ 1,625	$ 2,740
2	3	6,089	9,180
5	2	2,044	5,280
6	1	4,763	6,550
	Total	$14,521	$23,750

Source: Stanley Consultants

ENVIRONMENTAL IMPACT OF SELECTED PLAN

The selected plan incorporates sewer separation alternatives 1, 2, and 3. These alternatives are similar in nature; therefore, the environmental impacts of these alternatives will be discussed together.

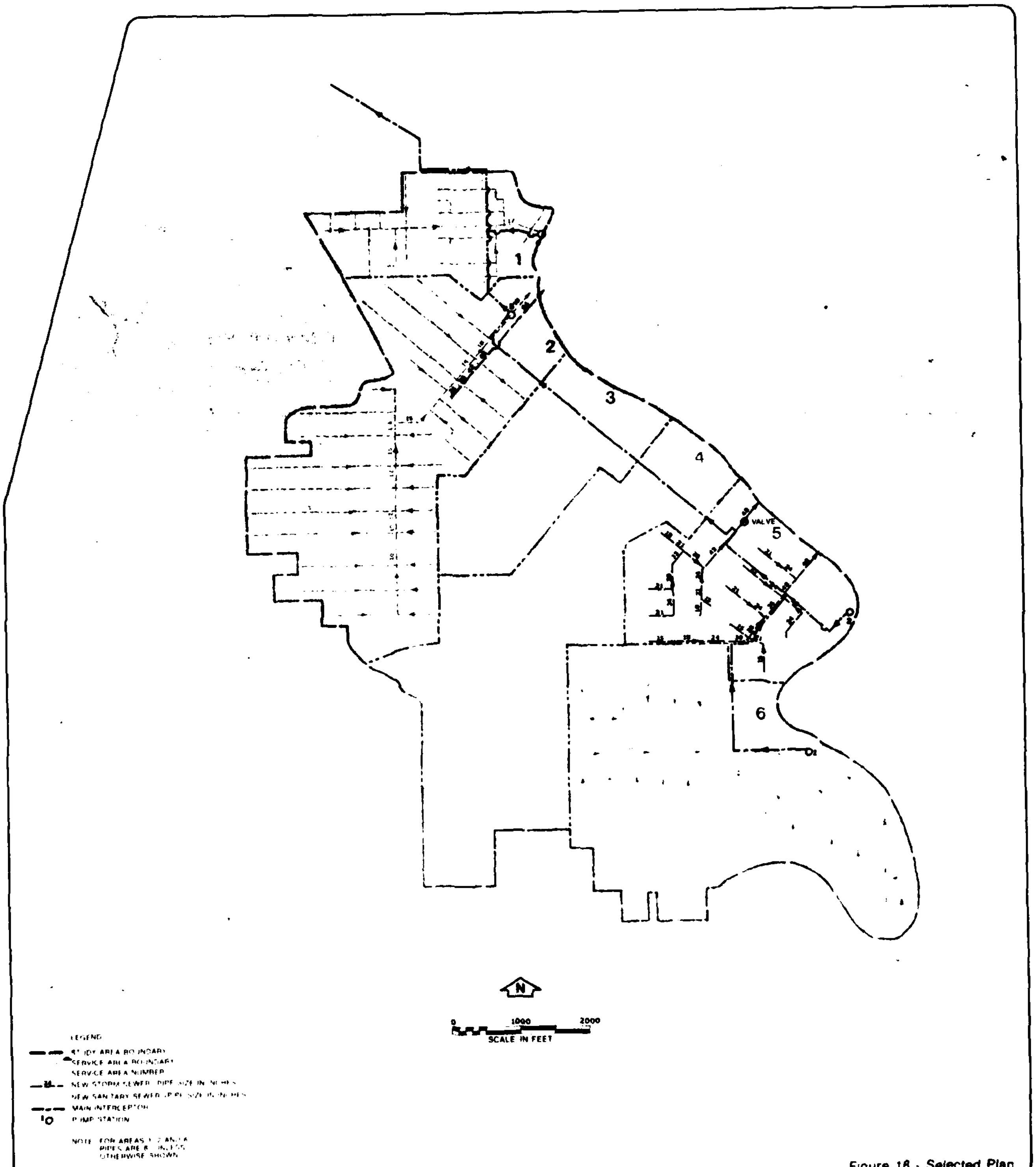

Figure 18 - Selected Plan

The significant long-term impacts of the selected plan are beneficial, while the short-term impacts are generally adverse. Sewer separation eliminates the discharge of sanitary wastes into the Red River of the North. Elimination of these wastes will improve the water quality of the river. Alternatives 2 and 3 will greatly reduce street flooding. All three alternatives will eliminate basement backups and improved public health conditions will result. Sewer separation should receive favorable public acceptance as this public service is improved.

Adverse impacts would occur during construction activities. Examples include increased sediment production, increased noise, higher levels of dust, inconvenience to residents, and damage to landscaped areas and trees. These impacts are temporary and/or can be mitigated.

Because the study area is almost completely developed, no significant impacts to population or community growth are expected. No additional significant long-term impacts to environmental, social, or economic factors are expected.

IMPLEMENTATION STEPS

The remaining steps for completing the project are listed below. The schedule assumes prompt review and approval of each step.

1. Submit Step 2 grant application for review by North Dakota State Department of Health and U.S. Environmental Protection Agency. Approval anticipated by mid-1980.
2. Preparation of plans and specifications for the selected plan. This will take approximately 1 year after the Step 2 grant has been approved.
3. Submit the plans and specifications and a Step 3 grant application to the North Dakota State Department of Health

and the U.S. Environmental Protection Agency for review. Approval anticipated by the end of 1981.

4. Bidding and award of construction contract. Construction anticipated to begin in early 1982.

INSTITUTIONAL RESPONSIBILITIES

The entire project is located within the Grand Forks city limits. The city will be responsible for implementation of the new sewer system. No significant institutional changes would be required for implementation of the selected plan.

FINANCIAL REQUIREMENTS

The total estimated project cost for the selected plan is $14,521,000 based on May 1979 price levels. The actual cost will be somewhat higher reflecting inflation from 1979 to the actual construction date. Construction is not anticipated to begin until 1982. Total estimated cost of the project based on 1982 dollars is 18.3 million dollars. The project is eligible for grants which will pay 75 percent of the pollution control portion of the cost. It is anticipated that a majority of the costs associated with the project will be eligible for EPA funding. However, in areas where new storm sewers are constructed, some portion of the cost will be allocated to flood control. Some items, such as new catch basins, are not eligible for EPA funding. In sections where new sanitary sewers are constructed, costs eligible for EPA funding include the cost of the collection systems and the Y-fittings designed for the connection of individual services to the sewer. However, the remaining costs associated with the connection of individual residences and businesses to the new sanitary sewers would not be eligible for EPA funding.

The exact amount which will be eligible for EPA funding cannot be determined at this time. However, preliminary estimates

indicate that as much as 17.5 million dollars of the project may be allocated to pollution control. If 17.5 million dollars of the project is allocated to pollution control, it is anticipated that approximately 13.1 million dollars would be obtained from Federal grants. This would leave 5.2 million dollars to be financed by Grand Forks. Discussions with city officials indicate that the 5.2 million dollars would come from special assessments of properties located within the combined sewer area. The assessments will vary with lot size and from one service area to another. The assessments are anticipated to range from approximately $1,450 to $1,850 for an average size lot in the combined sewer area. It is anticipated that the assessments will be paid as a lump sum amount when the project is completed, or at the option of the property owner, the cost could be paid over a period of 15 years with the property owner paying 1/15 of the assessment (approximately 100 to 125 dollars) each year plus interest on the unpaid balance of the assessment.

Grand Forks will be responsible for operation and maintenance of the system. The additional operation and maintenance costs associated with the new sewers which would be constructed as a part of this project are estimated to be $13,060 per year. The cost to a typical family living in the combined sewer area for operation and maintenance expenses is estimated to be approximately $0.35 per month.

REFERENCES

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2. Department of the Army, U.S. Corps of Engineers, St. Paul District, Urban Water Resources Study, Grand Forks-East Grand Forks Stage 2 Wastewater Study - Problem Identification/ Alternative Formulation/Evaluation, April 1978.

3. Department of the Army, U.S. Corps of Engineers, St. Paul District, Red River of the North Basin Study, April 1977.

4. 1979 Water Quality Data provided by the city of Grand Forks.

5. Minnesota Pollution Control Agency, Storet Data Summary Through 1976, November 1976.

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9. Richmond Engineering, Inc., Inflow, Infiltration Analysis, Step 1 Grant, City of Grand Forks, 1975.

10. U.S. Environmental Protection Agency, Guidance for Preparing a Facility Plan, Washington, D.C., May 1975.

11. Pitt, Robert, "The Use of Street Cleaning Operations in Reducing Urban Runoff Pollution," paper presented at Environmental Protection Agency Technology Transfer Seminar Series on Combined Sewer Overflow Assessment and Control Procedures, Chicago, Illinois, July 1978.

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13. U.S. Department of Commerce, National Oceanic and Atmospheric Administration, ten years of daily rainfall data for Grand Forks, North Dakota FAA Station, Asheville, North Carolina 1969-1978.

14. United States Environmental Protection Agency, Disinfection/Treatment of Combined Sewer Overflows, EPA-600/2-79-134, August 1979.

15. United States Environmental Protection Agency, The Swirl Primary Separator, EPA-600/2-78-122, August 1978.

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17. United States Environmental Protection Agency, Relationship Between Diameter and Height for the Design of a Swirl Concentrator as a Combined Sewer Overflow Regulator, EPA-670/2-74-039.

18. United States Environmental Protection Agency, The Dual Functioning Swirl Combined Sewer Overflow Regulator/Concentrator, EPA-670/2-73-059, September 1973.

19. United States Environmental Protection Agency, The Swirl Concentrator as a Combined Sewer Overflow Regulator Facility, EPA-R2-72-008, September 1972.

20. United States Environmental Protection Agency, Design Criteria for Mechanical, Electric, and Fluid System and Component Reliability, EPA-430-99-74-001,

ATTACHMENT A

NPDES PERMIT

Environmental Control

DIVISION OF WATER SUPPLY
AND POLLUTION CONTROL

NORMAN L. PETERSON, P.E.
DIRECTOR
(701) 224-2354

North Dakota State
Department of Health

JONATHAN B. WEISBUCH, M.D.
STATE HEALTH OFFICER

W. VAN HEUVELEN, CHIEF
ENVIRONMENTAL CONTROL

Missouri Office Building
1200 Missouri Avenue
Bismarck, North Dakota 58505

December 29, 1978

Mr. Frank Orthmeyer
City Engineer
Grand Forks, ND 58201

Gentlemen:

Attached is your permit for discharge under the North Dakota Pollutant Discharge Elimination System (NDPDES). If you have any questions as per attached permit, please contact this Department at (701) 224-2354.

Sincerely,

Norman L. Peterson
Director

NLP:SK:ff

PERMIT NO: ND-0022888

Effective Date: January 1, 1979

Expiration Date: December 31, 1983

AUTHORIZATION TO DISCHARGE UNDER THE

NORTH DAKOTA POLLUTANT DISCHARGE ELIMINATION SYSTEM

In compliance with North Dakota State Department of Health Regulation R61-28-01 as promulgated under Chapter 61-28 of the North Dakota Century Code, the

City of Grand Forks

is authorized to discharge from its sewage lagoons and other outfalls as specified,

to the Red River of the North

in accordance with effluent limitations, monitoring requirements and other conditions set forth in Parts I, II, and III, hereof.

This permit and the authorization to discharge shall expire at midnight,

December 31, 1983.

[signature] — 12-29-78

AUTHORIZED PERMITTING OFFICIAL — DATE

Director, Division of Water Supply and Pollution Control

TITLE

Location of Discharge Points:

Discharge 001

Lift station overflow, Latitude 47 degrees, 54 minutes, 50 seconds. Longitude 97 degrees, 01 minutes, 14 seconds.

Discharge 002

Lift station overflow, Latitude 47 degrees, 55 minutes, 13 seconds. Longitude 97 degrees, 01 minutes, 02 seconds.

Discharge 003

Lift station overflow, Latitude 47 degrees, 55 minutes, 35 seconds. Longitude 97 degrees, 01 minutes, 43 seconds.

Discharge 004

Lift station overflow, Latitude 47 degrees, 56 minutes, 6 seconds. Longitude 97 degrees, 02 minutes, 14 seconds.

Discharge 005

Lift station overflow, Latitude 47 degrees, 55 minutes, 53 seconds. Longitude 97 degrees, 02 minutes, 17 seconds.

Discharge 006

Emergency bypass, Latitude 47 degrees, 54 minutes, 22 seconds. Longitude 97 degrees, 01 minutes, 30 seconds.

Discharge 007

Emergency bypass, Latitude 47 degrees, 56 minutes, 43 seconds.
Longitude 97 degrees, 04 minutes, 03 seconds.

Discharge 008

Emergency bypass, Latitude 47 degrees, 56 minutes, 43 seconds.
Longitude 97 degrees, 04 minutes, 03 seconds.

Discharge 009

Sewage lagoons, Latitude 47 degrees, 58 minutes, 37 seconds.
Longitude 97 degrees, 03 minutes, 31 seconds.

Discharge 010

Emergency bypass, Latitude 47 degrees, 56 minutes, 36 seconds.
Longitude 97 degrees, 03 minutes, 11 seconds.

Discharge 011

Storm sewer overflow, Latitude 47 degrees, 55 minutes, 25 seconds.
Longitude 97 degrees, 01 minutes, 31 seconds.

Discharge 012

Storm sewer overflow, Latitude 47 degrees, 55 minutes, 42 seconds.
Longitude 97 degrees, 01 minutes, 56 seconds.

A. EFFLUENT LIMITATIONS AND MONITORING REQUIREMENTS - SEE ANY ADDITIONAL REQUIREMENTS UNDER PART III.

1. Effluent Limitations for Discharge 009*

Effective January 1, 1979 and lasting through December 31, 1983 the quality of effluent discharged by the facility shall, as a minimum, meet the limitations as set forth below:

No discharge shall occur from the subject facility unless and until permission for such discharge is granted by the State of North Dakota Department of Health. In the event such permission is granted by the Department, the permittee shall comply with the effluent limitations specified below. In addition, there shall be no visible floating solids and/or visible oil or grease in the discharge.

Average Effluent Concentration

Parameter	30 Consecutive Day Period	7 Consecutive Day Period
BOD_5 - mg/l	25 a/	45 b/
Total Suspended Solids - mg/l	30 a/	45 b/
Fecal Coliform - Number/100 ml	200 c/	400 c/
pH - Units	Shall remain between 6.0 and 9.0 d/	
Oil and Grease - mg/l	10 d/	

a/ This limitation shall be determined by the arithmetic mean of a minimum of three (3) consecutive samples taken on separate weeks in a 30-day period (minimum total of three (3) samples); not applicable to fecal coliforms - see footnote c/.

b/ This limitation shall be determined by a single properly preserved grab sample; not applicable to fecal coliforms - see footnote c/.

c/ Averages for fecal coliforms shall be determined by the geometric mean of a minimum of three (3) consecutive grab samples taken during separate weeks in a 30-day period for the 30-day average, and during separate days in a 7-day period for the 7-day average (minimum total of three (3) samples).

d/ Any single analysis and/or measurement beyond this limitation shall be considered a violation of the conditions of this permit.

*There shall be no discharge when there is an ice cover on the receiving waters.

2. Self-Monitoring Requirements for Discharge 009

As a minimum, the following parameters shall be monitored at the frequency and with the type of measurement indicated; samples of measurements shall be representative of the volume and nature of the monitored discharge. The permittee shall monitor his discharge(s) as shown below:

Parameter	Frequency	Type of Measurement
Total Flow - mgd	a/	Instantaneous b/
Total BOD_5 - mg/l	c/ - d/	Grab b/
Total Suspended Solids - mg/l	c/ - d/	Grab b/
Fecal Coliforms - number/100 ml	d/	Grab b/
pH - units	d/	Grab b/
Oil and Grease - mg/l	d/	Visual

a/ Flow shall be reported as the maximum value for which the discharge facility was designed at the given hydraulic head.

b/ See definitions, Part C.

c/ In addition to monitoring the final discharge, influent samples shall be taken and analyzed for this parameter at the same frequency as required for this parameter in the discharge.

d/ Sampling shall consist of one (1) grab sample to be taken and analyzed prior to any discharge. This analysis shall be reported to the State of North Dakota at the address given in Part I, C of this permit. No discharge shall occur from the facility until an analysis is evaluated and permission is granted to discharge by the State of North Dakota. In addition, one (1) grab sample per week shall be taken, analyzed, and reported immediately to the State of North Dakota for the duration of the discharge.

Discharge Duration

If the rate of discharge is controlled, the rate and duration of discharge shall be reported.

Flow Measurement

No later than July 1, 1981 a flow-measuring device, if not already present, shall be installed within the wastewater plant circuit to give a representative value of effluent volume.

A. EFFLUENT LIMITATIONS AND MONITORING REQUIREMENTS - SEE ANY ADDITIONAL REQUIREMENTS UNDER PART III.

3. Self-Monitoring Requirements for Discharges 001, 002, 003, 004, 005, 006, 007, 008, 010, 011, and 012.

Discharges from the above-named discharge points are prohibited except where unavoidable to prevent loss of life or severe property damage. In the event of a discharge from any of these points, the Deparmtent shall be notified as soon as possible by telephone (701+224-2354). The permit-issuing authority reserves the right to request the permittee to analyze the water quality of any of these discharges. In addition, the following information shall be supplied to the Department within twenty days of the discharge.

1) Location of discharge(s) by serial number

2) Dates of discharge(s)

3) Approximate total flow of the discharge(s)

4) Explanation of circumstances causing the discharge(s)

5) Results of any laboratory testing of the discharge(s), if requested

B. SCHEDULE OF COMPLIANCE - OUTFALLS 001, 002, 003, 004, 005, 011, 012

No later than October 1, 1979, the permittee shall provide the North Dakota State Department of Health with an acceptable report containing the results of a detailed engineering evaluation to determine the most cost-effective method of minimizing or eliminating the combined sewer overflows from outfalls 001, 002, 003, 004, 005, 011, and 012. This study shall include a description of and cost estimates for the various available abatement operations together with the anticipated reductions expected in the discharge concentration and discharge amounts of fecal coliforms, BOD, and suspended and floatable solids.

Within 60 days of the submittal of an acceptable report, but no later than December 1, 1979, the North Dakota State Department of Health and the US Environmental Protection Agency shall determine the most cost-effective approach to minimize or eliminate the discharges from outfalls 001, 002, 003, 004, 005, 011, and 012.

Within 60 days of notification of the most cost-effective means, but no later than February 1, 1980, the permittee shall select a means of controlling the overflows which shall provide at a minimum, the abatement provided by the most cost-effective procedure. A compliance schedule shall also be submitted to the North Dakota State Department of Health and the US Environmental Protection Agency by February 1, 1980, including, at a minimum, dates to accomplish the following:

1. Submit an acceptable Step II application for combined sewer controls.
2. Completion of preliminary plans.
3. Completion of final plans.
4. Submit an acceptable Step III application for combined sewer controls.
5. Awarding of contracts.
6. Commencement of construction.
7. Completion of major construction phases.
8. Completion of all construction.
9. Attainment of operational level.

Upon approval of the compliance schedule by the permit-issuing authority, the compliance schedule shall become conditions of the permit.

No later than 14 calendar days following a date identified in the above schedule of compliance, the permittee shall submit either a report of progress, or, in the case of specific actions being required by identified dates, a written notice of compliance or noncompliance. In the latter case, the notice shall include the cause of noncompliance, any remedial actions taken, and the probability of meeting the next scheduled requirement.

C. MONITORING AND REPORTING

1. Representative Sampling

Samples and measurements taken as required herein shall be representative of the volume and nature of the monitored discharge.

2. Reporting

Monitoring results shall be summarized and reported on the appropriate Discharge Monitoring Report Form. Each report shall cover a period of one months. The first period shall be Jan 1 to Jan 31. The second period shall be Feb 1 to Feb 28. All reports must be postmarked by the 28th day of the month following the end of each reporting period. The first report must be postmarked by 2-28-79. Duplicate signed copies of these, and all other reports required herein, shall be submitted to the Department and the Regional Administrator at the following addresses: If no discharge occurs during the reporting period, "no discharge" shall be reported.

(a) North Dakota State Department of Health
Division of Water Supply and Pollution Control
1200 Missouri Avenue
Bismarck, North Dakota 58505

(b) U. S. Environmental Protection Agency
Suite 900, 1860 Lincoln Street
Denver, Colorado 80295

ATTENTION: Enforcement - Permits

3. Definitions

a. A "composite" sample, for monitoring requirements, is defined as a minimum of four (4) grab samples collected at equally spaced two (2) hour intervals and proportioned according to flow.

b. A "grab" sample, for monitoring requirements, is defined as a single "dip and take" sample collected at a representative point in the discharge stream.

c. An "instantaneous" measurement, for monitoring requirements, is defined as a single reading, observation, or measurement using existing monitoring facilities.

d. The "Act" means the Federal Water Pollution Control Act Amendments of 1972, PL 92-500.

e. The "Administrator" means the administrator of the United States Environmental Protection Agency.

f. The "Department" means the North Dakota State Department of Health, Division of Water Supply and Pollution Control.

g. The "EPA" means the United States Environmental Protection Agency.

h. The "Regional Administrator" means the administrator of the region of EPA with jurisdiction over federal water pollution control activities in the State of North Dakota.

4. Test Procedures

Test procedures for the analysis of pollutants shall conform to regulations published pursuant to Section 304(g) of the Act, under which such procedures may be required. All flow measuring and flow-recording devices used in obtaining data submitted in self-monitoring reports must indicate values within 10 percent of the actual flow being measured.

5. Recording of Results

For each measurement or sample taken pursuant to the requirements of this permit, the permittee shall record the following information:

a. The exact place, date, and time of sampling;

b. The dates the analyses were performed;

c. The person(s) who performed the analyses;

d. The analytical techniques or methods used; and

e. The results of all required analyses.

6. Additional Monitoring by Permittee

If the permittee monitors any pollutant at the location(s) designated herein more frequently than required by this permit, using approved analytical methods as specified above, the results of such monitoring shall be included in the calculation and reporting of the values required on the appropriate Discharge Monitoring Report Form. Such increased frequency shall also be indicated.

7. Records Retention

All records and information resulting from the monitoring activities required by this permit including all records of analyses performed and calibration and maintenance of instrumentation and recordings from continuous monitoring instrumentation shall be retained for a minimum of three (3) years, or longer if requested by the Department or Regional Administrator.

A. MANAGEMENT REQUIREMENTS

1. Change in Discharge

All discharges authorized herein shall be consistent with the terms and conditions of this permit. The discharge of any pollutant identified in this permit more frequently than or at a level in excess of that authorized shall constitute a violation of the permit. Any anticipated facility expansions, production increases, or process modifications which will result in new, different, or increased discharges of pollutants must be reported by a submission of a new NDPDES application or, if such changes will not violate the effluent limitations specified in this permit, by notice to the Department of such changes. Following such notice, the permit may be modified to specify and limit any pollutants not previously limited.

2. Noncompliance Notification

If, for any reason, the permittee does not comply with or will be unable to comply with any maximum effluent limitation specified in this permit, the permittee shall provide the Department and Regional Administrator with the following information, in writing, within five (5) days of becoming aware of such condition:

a. A description of the discharge and cause of noncompliance; and

b. The period of noncompliance, including exact dates and times; or, if not corrected, the anticipated time the noncompliance is expected to continue, and steps being taken to reduce, eliminate and prevent recurrence of the noncomplying discharge.

3. Facilities Operation

The permittee shall at all times maintain in good working order and operate as efficiently as possible all treatment or control facilities or systems installed or used by the permittee to achieve compliance with the terms and conditions of this permit.

4. Adverse Impact

The permittee shall take all reasonable steps to minimize any adverse impact to navigable waters resulting from noncompliance with any effluent limitations specified in this permit, including such accelerated or additional monitoring as necessary to determine the nature and impact of the noncomplying discharge.

5. Bypassing

Any diversion from or bypass of facilities necessary to maintain compliance with the terms and conditions of this permit is prohibited except (i) where unavoidable to prevent loss of life or severe property damage, or

(ii) where excessive storm drainage or runoff would damage any facilities necessary for compliance with the effluent limitations and prohibitions of this permit. The permittee shall promptly notify the Department and Regional Administration in writing of each such diversion or bypass.

If for other reasons, a partial or complete bypass of the wastewater facilities is considered necessary, a request for such bypass shall be submitted to the Department and to the Regional Administrator at least sixty (60) days prior to the proposed bypass. If the proposed bypass is judged acceptable by the Department and by the Regional Administrator, the bypass will be allowed subject to limitation imposed by the Department and the Regional Administrator.

If, after review and consideration, the proposed bypass is determined to be unacceptable by the Department and the Regional Administrator, or if limitations imposed on an approved bypass are violated, such bypass shall be considered a violation of this permit; and the fact that application was made, or that a partial bypass was approved, shall not be defense to any action brought thereunder.

6. Removed Substances

Solids, sludges, filter backwash, or other pollutants removed in the course of treatment or control of wastewaters shall be disposed of in a manner such as to prevent any pollutant from such materials from entering navigable waters.

7. Power Failures

In order to maintain compliance with the effluent limitations and prohibitions of this permit, the permittee shall either:

a. In accordance with the Schedule of Compliance contained in Part I, provide an alternative power source sufficient to operate the wastewater control facilities;

or, if such alternative power source is not in existence, and no date for its implementation appears in Part I,

b. Take such precautions as are necessary to maintain and operate the facility under his control in a manner that will minimize upsets and ensure stable operation until power is restored.

B. RESPONSIBILITIES

1. Right of Entry

The permittee shall allow the head of the Department, the Regional Administrator, and/or their authorized representatives, upon the presentation of credentials:

a. To enter upon the permittee's premises where an effluent source is located or in which any records are to be kept under the terms and conditions of this permit; and

b. At reasonable times to have access to and copy any records required to be kept under the terms and conditions of this permit; to inspect any monitoring equipment or monitoring method required in this permit; and to sample any discharge of pollutants.

2. Transfer of Ownership or Control

In the event of any change in control or ownership of facilities from which the authorized discharges emanate, the permittee shall notify the succeeding owner or controller of the existence of this permit by letter, a copy of which shall be forwarded to the Department and Regional Administrator.

3. Availability of Reports

Except for data determined to be confidential under Section 308 of the Act, all reports prepared in accordance with the terms of this permit shall be available for public inspection at the offices of the State Water Pollution Control Agency and the Regional Administrator. As required by the Act, effluent data shall not be considered confidential. Knowingly making any false statement on any such report may result in the imposition of criminal penalties as provided for in Section 309 of the Act.

4. Permit Modification

After notice and opportunity for a hearing, this permit may be modified, suspended or revoked in whole or in part during its term for cause including, but not limited to, the following:

a. Violation of any terms or conditions of this permit;

b. Obtaining this permit by misrepresentation or failure to disclose fully all relevant facts; or

c. A change in any condition that requires either a temporary or permanent reduction or elimination of the authorized discharge.

5. Toxic Pollutants

Notwithstanding Part II, B-4 above, if a toxic effluent standard or prohibition (including any schedule of compliance specified in such effluent standard or prohibition) is established under Section 307(a) of the Act for a toxic pollutant which is present in the discharge and such standard or prohibition is more stringent than any limitation for such pollutant in this permit, this permit shall be revised or modified in accordance with the toxic effluent standard or prohibition and the permittee so notified.

6. Civil and Criminal Liability

Except as provided in permit conditions on "Bypassing" (Part II, A-5) and "Power Failures" (Part II, A-7), nothing in this permit shall be construed to relieve the permittee from civil or criminal penalties for noncompliance.

7. Oil and Hazardous Substance Liability

Nothing in this permit shall be construed to preclude the institution of any legal action or relieve the permittee from any responsibilities, liabilities, or penalties to which the permittee is or may be subject under Section 311 of the Act.

8. Property Rights

The issuance of this permit does not convey any property rights in either real or personal property, or any exclusive privileges, nor does it authorize any injury to private property or any invasion of personal rights, nor any infringement of Federal, State or local laws or regulations.

9. Severability

The provisions of this permit are severable, and if any provision of this permit, or the application of any provision of this permit to any circumstance, is held invalid, the application of such provision to other circumstances, and the remainder of this permit, shall not be affected thereby.

OTHER REQUIREMENTS

Industrial Wastes

A. Each major contributing industry must be identified as to qualitative and quantitative characteristics of the discharge as well as production data. Such information shall be submitted within one hundred twenty (120) days of the issuance of this permit. A major contributing industry is defined as an industrial user discharging to a municipal treatment works that satisfies any of the following: (1) has a flow of 50,000 gallons or more per average work day; (2) has a flow greater than five percent of the flow carried by the municipal system receiving the waste; (3) has in its waste a toxic pollutant in toxic amounts as defined under Section 307(a) of the Clean Water Act of 1977 (Federal Register dated January 31, 1978); or (4) is found by the permit issuing authority to have a significant impact on the treatment works or the quality of effluent from the municipal treatment works.

B. The permittee must notify the permitting authority of any new introductions by new or existing sources or any substantial change in pollutants from any major industrial source. Such notice must contain the information described in "A" above and be forwarded no later than sixty (60) days following the introduction or change.

C. Pretreatment Standards (40 CFR, Subchapter D--Water Programs) developed pursuant to Section 307 of the Act require that under no circumstances shall the permittee allow introduction of any of the following wastes into the waste treatment system from any contributing industry:

(1) Wastes which create a fire or explosion hazard in the publicly owned treatment works.

(2) Wastes which will cause corrosive structural damage to treatment works, but in no case, wastes with a pH lower than 5.0, unless the works are designed to accomodate such wastes.

(3) Solid or viscous substances in amounts which would cause obstruction to the flow in sewers, or other interference with the proper operation of the publicly owned treatment works.

OTHER REQUIREMENTS (Continued)

(4) Wastewaters at a flow rate and/or pollutant discharge rate which is excessive over relatively short time periods so that there is a treatment process upset and subsequent loss of treatment efficiency.

D. In addition to the general limitations expressed above, more specific pretreatment limitations have been and will be promulgated for specific industrial categories under Section 307 of the Act, including but not limited to, those listed below. Compliance with these regulations is required no later than three (3) years following the date of promulgation: (See 40 CFR, Subchapter D, Parts 400 through 500, for specific information).

Automatic and Other Laundries
Coal Mining
Electroplating
Inorganic Chemicals Manufacturing
Iron and Steel Manufacturing
Leather Tanning and Finishing
Machinery and Mechanical Products Manufacturing
Miscellaneous Chemicals Manufacturing
Nonferrous Metals Manufacturing
Ore Mining
Organic Chemicals Manufacturing
Paint and Ink Formulation and Printing
Paving and Roofing Materials
Petroleum Refining
Plastic and Synthetic Materials Manufacturing
Pulp and Paperboard Mills and Converted Paper Products
Rubber Processing
Soap and Detergent Manufacturing
Steam Electric Power Plants
Textile Mills
Timber Products Processing

E. At such time as a specific pretreatment limitation becomes applicable to an industrial contributor, the permit issuing authority may, as appropriate, do the following:

(1) Amend the NPDES discharge permit to specify the additional pollutant(s) and corresponding effluent limitation(s) consistent with the applicable National pretreatment limitation;

(2) Require the permittee to specify, by ordinance, contract, or other enforceable means, the type of pollutant(s) and the maximum amount which may be discharged to the permittee's facility for treatment;

OTHER REQUIREMENTS (Continued)

(3) Require the permittee to monitor its discharge for any pollutant which may likely be discharged from the permittee's facility, should the industrial contributor fail to properly pretreat its waste.

The permit issuing authority retains, at all times, the right to take legal action against the industrial contributor or the treatment works, in those cases where a permit violation has occurred because of the failure of an industrial contributor to discharge at an acceptable level. If the permittee has failed to properly delineate maximum acceptable industrial contributor levels, the permitting authority will look primarily to the permittee as the responsible party unless the contributor's discharge is obviously unacceptable under 40 CFR, Subchapter D - Water Programs.

Violations Resulting from Overloading

Should overloading of the wastewater treatment facilities result in a violation of this permit, the North Dakota State Department of Health and/or EPA may request from a court of competent jurisdiction, a restriction to prohibit any additional connections to the wastewater facilities covered by this permit. This authority is established under Section 402(h) of the Clean Water Act and Section 61-28-08 of the North Dakota Century Code.

Compliance with Construction Grant Procedures

Any permittee, receiving construction grant funds, shall comply with the construction grant provisions, Section 201(b) through (g) of the Clean Water Act.

Staffing and Laboratory

The permittee shall provide adequate process controls, staffing, and training, necessary to operate the facilities in an efficient manner. The permittee shall provide or have available adequate laboratory services commensurate with the type of treatment facilities being operated.

REAPPLICATION

Any permittee, wishing to have its permit renewed, shall reapply at least one-hundred eighty(180) days prior to the expiration date of the existing permit. The reapplication may be made on forms provided by the issuing agency.

ATTACHMENT B

SUMMARY OF PUBLIC HEARING

SUMMARY OF PUBLIC HEARINGS
FOR FACILITIES PLANNING STUDY
FOR CITY OF GRAND FORKS

A Public Hearing was held at 3:00 p.m. on Monday, 3 March 1980, in the Council Chambers at City Hall to present and discuss alternatives for eliminating the discharge of untreated combined sewer overflows to the Red River of the North at Grand Forks. Those present at the meeting included the following:

Andrew Stewart	1615 1st Avenue North
Mr. & Mrs. Axel Erickson	1108 5th Avenue North
Jerome Borgen	1616 Mill Road
Tom McMahon	1616 Mill Road
Elmer Branvold	802 South 9th Street
Arthur Ostad	728 South 9th Street
Marvin E. Goebel	1009 South 11th Street
Dan S. Boyce	City Chemist, Water Department
Don Tingum	City Auditor, City of Grand Forks
Dan Johnson	Engineer, City of Grand Forks
John H. Beasley	Stanley Consultants
J. Keith Johnson	Asst. City Engineer, City of Grand Forks
Frank Orthmeyer	Director of Public Works & City Engineer, City of Grand Forks
Lois Sorum	924 10th Avenue South
James Deraney	1102 4th Avenue North
Maurine Deraney	1102 4th Avenue North
Neome Bushaw	Grand Forks City Council
Bill Kuhl	1115 North 20th Street
Roni Bohlman	Secretary, City of Grand Forks

Neome Bushaw, a member of the Grand Forks City Council, opened the public hearing. Frank Orthmeyer, City Engineer, then made the opening statements. He stated that the public

hearing dealt with the storm sewer separation project, and that the project would be addressed in two parts: (1) facilities plan and (2) environmental impacts of various alternatives (second public hearing). Mr. Orthmeyer then introduced John Beasley of Stanley Consultants.

Mr. Beasley stated that the purpose of the study was to find a solution to correct combined sewer overflow problems in Grand Forks. He added that the public hearing was a requirement of the EPA. He then referred to the six subareas as shown on figure 1 of the Stage 3 Wastewater Study - Grand Forks Combined Sewer Analysis Draft Report. He pointed out that sewer separation projects are under way in subareas 3 and 4. He indicated that the current study looked at subareas 1, 2, 5 and 6, which make up about 850 acres of mostly residential development.

Beasley pointed out that during storms the combined sewer pump station capacities are exceeded; this happens several times each year. As a result, potential health problems arise because sanitary sewage overflows into the river which also serves as domestic water supply for Grand Forks. There is also localized basement and street flooding caused by combined sewer backups. EPA is now requiring that the city of Grand Forks correct these problems, and the current study was undertaken to develop alternatives and recommend a plan for solving the combined sewer overflow problem.

The following alternatives were evaluated:

1. Sewer separation
2. Swirl concentrators
3. Detention and treatment
4. Source and collection system management
5. Relocating the water intake mains

Relocating the water intakes proved to be very costly and still did not solve the problem. Source and collection system

management which includes better street sweeping, main flushing, basin cleaning, etc., is needed, but as a supplement to the other alternatives. The remaining alternatives were developed in detail.

One of the main considerations is the cost of the alternatives. Mr. Beasley pointed out the cost of the various alternatives in 1979 dollars. They are as follows:

	Alternative	Costs/Initial
1.	Use existing sewer as storm sewer - build new sanitary sewers	$13,972,000
2.	Use existing sewer as sanitary sewer - build new storm sewers	17,047,000
3.	Build new sanitary and new storm sewer - also utilize existing sewer system	18,287,000
4.	Build new sanitary and new storm sewer - do not use old system	27,562,000
5.	Filtration treatment - in each service area	25,530,000
6.	Filtration treatment - at single site	36,125,000
7.	Sedimentation treatment - in each service area	22,891,000
8.	Sedimentation treatment - at single site	34,986,000
9.	Swirl concentrators	16,699,000

After detailed evaluation, a combination of sewer separation alternatives were recommended for the four areas. They are as follows:

Area 1 (88 acres) - Utilize old system as storm sewers and build new sanitary system. The cost would be approximately $1,600,000 (1979 dollars).

Area 2 (307 acres) - Utilize old system as storm sewers and build new sanitary system with some new storm sewers. The cost would be approximately $6,100,000 (1979 dollars).

Area 5 (139 acres) - Utilize old system as sanitary sewers and build new storm system. The cost would be approximately $2,000,000 (1979 dollars).

Area 6 (316 acres) - Utilize old system as storm sewers and build new sanitary system. The cost would be approximately $4,700,000 (1979 dollars).

Projected cost for the year 1982 for the four areas would total approximately $18.3 million. It is anticipated that EPA will pay 75 percent of the pollution control portion of the cost, which would total approximately $13.1 million. The remaining local cost would amount to about $5.2 million which would be assessed to the property owners. The cost to the property owner would range from approximately $1,450 to $1,850 with an average of about $1,650

Discussion followed the presentation by Mr. Beasley.

Q: Marvin Goebel - 1009 South 11th Street - Why weren't Stanley Consultants involved with sewer separation projects in areas 3 and 4?

A: Mr. Orthmeyer - The reason that Stanley was not involved with these projects was that they were started before the current study was started. About 5 years ago, the city had a Facilities Plan before EPA for funding which included not only the sewer separation but lagoon expansion as well. The plan was under study in the North Dakota Department of Health Office and EPA office in Denver. The plan was delayed because the separation part was not adequately addressed. Two or three years ago, the Mayor, myself and Richmond, our consultant, met with EPA. EPA asked the city to remove the separation part from the Facilities Plan. We consented to that. That is why the separation was not addressed at that time and consequently, we had to go back and restudy the sewer separation plan. In area 4, in which you live, the city had already started to separate that with urban renewal funds. One part of the first project which was not separated was the area south of DeMers Avenue and east of 13th.

It was decided to proceed using Community Development funds.

A: Mr. Beasley - Until the last couple of years, EPA was not funding very many of these types of projects. That is why th ty is attempting to take advantage of this program now. At the time of the original decision (to begin sewer separation projects) EPA was not funding many of these projects.

Q: Lois Sorum - 924 10th Avenue South - Why would EPA go for the lagoon expansion and not help residents with sewer separation costs?

A: Beasley - EPA felt its first priority was treatment of sanitary waste. Policy has now changed at the Federal and State levels.

Q: Mrs. Alex Erickson - 1108 5th Avenue North - Will we receive any help for the project that was done in our area?

A: Mr. Orthmeyer - I am sure that the Council has this under study. I feel that the Council will do all that they can. Your project was under construction contract and we felt it would be more expensive to the property owners if we got out of the contract.

Q: Mrs. Erickson - Could the project have waited?

A: Mr. Orthmeyer - Yes.

A: Mr. Beasley - There was no way the city could have foreseen that this would happen (that EPA would help with the funding for the other projects).

Q: Mr. Goebel - I feel that we should receive a share of the money from the other projects that may be funded by EPA for the project in our area.

A: Mr. Beasley - EPA monies are not retroactive.

A: Neome Bushaw - If the policy is changed (EPA's) and we are given this money, you will be assisted. $275,000 from

Community Development was given to the homeowners in this area for assistance.

Q: Bushaw - In reference to Goebel's statement that he feels the matter was definitely not right and that a problem still exists, Mrs. Bushaw asked how the city could have proceeded in a better manner?

A: Goebel - I don't know.

Q: Lois Sorum - How could funds be so shut off?

Q: Bushaw - These programs are always changing and it makes it very difficult for planning.

Q: Goebel - There must be something written that states that this was mandated. I spoke with Council members that stated that they never saw anything written. Where is this information?

A: Orthmeyer - It is on file.

It was then brought out that this public hearing is not to discuss areas 3 and 4, in which the projects are under way. The Public Hearing is being held for discussion regarding areas 1, 2, 5 and 6.

A second Public Hearing was held at 3:30 p.m. on Monday, 3 March 1980, in the Council Chambers at City Hall to present and discuss the environmental impacts of the various alternatives and the recommended plan. Those persons attending the meeting were the same as those who attended the 3:00 Public Hearing. Mrs. Neome Bushaw opened the meeting.

Mr. Beasley explained that there are long-term and short-term impacts to be considered when studying the alternatives available. He stated that the EPA requires the city to look at the impacts on wildlife, wetlands, and agricultural lands. The city had no problems with these areas, as the area being considered is mainly residential. The environmental analysis was presented. Stanley

Consultants found that there would be no long-term adverse impacts on the population or community growth in the city of Grand Forks.

A question and answer period followed the presentation.

Q: Mr. Marvin Goebel - 1009 South 11th Street - How long until the Federal Government tells you that you cannot run the stormwater into the river?

A: Who knows?

Q: Jerry Borgen - 1616 Mill Road - You were speaking of the total project in 1982 dollars. Does that imply that the entire project will be completed in 1982?

A: Beasley - No, it is doubtful that it will be done at one time. It would be possible to begin construction by 1982, but the project may not all be built in one year.

Q: Goebel - Do all cities within the United States along a stream become involved in this situation?

A: Beasley - Basically, all communities in this situation have to do something up to a certain point. It depends on the location and size of the river that the water is discharged into.

Q: Goebel - When will this come before the City Council?

A: Orthmeyer - This is the public hearing. There will not be a public hearing at another Council meeting. The plan will be accepted by the Council this summer. Then an application must be submitted to the EPA.

Q: Bushaw - When do we make application for funding?

A: Orthmeyer - After the plan is accepted. I would expect that we would be making application for monies in May or June.

Q: Bushaw - Are we committed to the project if EPA does not make a financial commitment to the city?

A: Orthmeyer - No.

Q: Goebel - How could this project be stopped?

A: Orthmeyer - The City Council could stop it.

The meeting adjourned at 4:30 P.M.

AFFIDAVIT OF PUBLICATION

STATE OF NORTH DAKOTA }
COUNTY OF GRAND FORKS } ss.

No. [illegible]

[illegible] of said State and County being first duly sworn, on oath says:

That { she / he } is { Advertising Clerk / Advertising Manager / General Manager } of GRAND FORKS HERALD, INC.,

publisher of the Grand Forks Herald, Evening Edition, a daily newspaper of general circulation, printed and published in the City of Grand Forks, in said County and State, and has been during the time hereinafter mentioned, and that the advertisement of Notice of Public Hearing a printed copy of which is hereto annexed, was printed and published in every copy of [illegible] issues of said newspaper, for a period of 2 consecutive times, to wit:

Feb. 3 1980	19
Feb. 16 1980	19
19	19
19	19

and that the full amount of the fee for the publication of the annexed notice inures solely to the benefit of the publishers of said newspaper; that no agreement or understanding for a division thereof has been made with any other person and that no part thereof has been agreed to be paid to any person whomsoever and the amount of said fee is $ [illegible];

That said newspaper was, at the time of the aforesaid publication, the duly elected and qualified Official Newspaper within said County, and qualified in accordance with the law of the State of North Dakota to do legal printing in said County and State.

[illegible]

Subscribed and sworn to before me this 3rd day of March A. D. 1980

Elaine Fawcett
Notary Public, Grand Forks, N. D.

ELAINE [illegible] FAWCETT
Notary Public, [illegible]
My Commission [illegible]

NOTICE OF PUBLIC HEARING

Notice is hereby given that the city of Grand Forks, North Dakota, will hold two public hearings concerning the following proposed project:

Approximately 830 acres of Grand Forks is served with a combined sewer system. During storms, quantities of storm water runoff mixed with sanitary wastewater are discharged to the Red River of the North through overflow structures on the combined sewer system. The U.S. Environmental Protection Agency has issued a discharge permit directing Grand Forks to eliminate or significantly reduce the pollution load from the combined sewer overflows into the Red River of the North. A study has been conducted to evaluate a wide range of possible solutions to meet requirements of the discharge permit.

A public hearing will be held on Monday, March 3, 1980 at 2:30 p.m. in the council chambers in City Hall. Representatives of Stanley Consultants will present and discuss alternatives for eliminating the discharge of untreated combined sewer overflows to the Red River of the North at Grand Forks. Alternatives which have been studied include the construction of a new separate storm sewer system; a new separate sanitary sewer system; collection, storage, and treatment of combined sewer overflows; and combinations of the above. The recommended plan consists of construction of a new sanitary sewer system in a majority of the combined sewer area with new storm sewers recommended in a few locations.

A second public hearing will be held on Monday, March 3, 1980, at 3:30 p.m. in the council chambers in City Hall, to present and discuss the environmental impacts of the various alternatives and the recommended plan.

Construction is not anticipated to begin until 1982. Total estimated cost of the project, based on 1982 dollars, is $18.3 million. The project is eligible for federal grants which will pay 75 percent of the pollution control portion of the cost. The exact amount which will be obtained from federal grants is not known at this time but is anticipated to be approximately $13.1 million. This leaves $5.2 million to be financed by Grand Forks. It is anticipated that this $5.2 million will come from special assessments of property located within the combined sewer area. The assessments will vary with lot size and from one service area to another. Although the exact assessments cannot be calculated at this time, they are anticipated to range from approximately $1,450 to $1,850 for an average size lot in the combined sewer area. It is anticipated that the assessments will be paid as a lump sum amount when the project is completed or over a period of 15 years with the property owner paying one-fifteenth of the assessment (approximately $100 to $125) each year plus interest on the unpaid balance of the assessment. Operation and maintenance of the new sewer system is estimated to cost $13,000 per year. The cost to a typical family living in the combined sewer area is expected to be approximately $0.25 per month for operation and maintenance of the new sewers.

A draft facilities planning report has been prepared for this project. Anyone wishing to review the report may do so by contacting the Public Works Director at the Grand Forks City Hall.

The purpose of the public hearings is to familiarize people with the study and to obtain formal comments from all concerned interests. Written comments will be received by the Public Works Director through March 5, 1980. A summary of the public hearing and a summary of any comments will be included with the final report.

Dated this 31st day of January, 1980.

DONALD O. TINGUM,
City Auditor

(SEAL)

(Feb. 3, 16, 1980)

ATTACHMENT C

CLEARINGHOUSE REVIEW

The State of North Dakota
FEDERAL AID COORDINATOR OFFICE
State Capitol Building
Bismarck, North Dakota 58505
(701) 224-2060

February 14, 1980

"LETTER OF CLEARANCE" IN CONFORMANCE WITH OMB CIRCULAR NO. A-95

To: City of Grand Forks

STATE APPLICATION IDENTIFIER: 8001164048

Mr. J. Keith Johnson, P.E.
City Engineer
P.O. Box 1518
Grand Forks, ND 58201

Dear Mr. Johnson:

Subject: Facility Plan by City of Grand Forks to Environmental Protection Agency for federal financial assistance for Combined Sewer Separation.

This plan was received in our office on January 16, 1980.

The above referenced plan has been reviewed through the North Dakota State Intergovernmental Clearinghouse in compliance with Office of Management and Budget Circular No. A-95. Based on the results of that review, the State Clearinghouse gives clearance to the project as described.

To document your compliance with Office of Management and Budget Circular No. A-95, this letter should be attached to your plan when you submit it to your funding agency.

This Clearinghouse requests the opportunity for complete re-review of applications for renewal or continuation grants or applications not submitted to or acted on by the funding agency within one year after the date of this letter.

Please use the above SAI number for reference to the above project with this office. Your continued cooperation in the review process is much appreciated.

Sincerely yours,

Bonnie A. Banks

Mrs. Leonard E. Banks
Coordinator
State Intergovernmental Clearinghouse

BAB/gd